EXPERIMENTAL WIRELESS
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Editorial.

The Wireless Patent Situation in U.S.A.

ALTHOUGH a patent is a form of monopoly and must therefore, of necessity, act to some extent as a restraint upon competition, it is directly approved and sanctioned by the State. The reason for this is that no more expedient method of encouraging industrial invention has yet been devised, and the advantages to be derived from the system are considered to greatly outweigh those imperfections which must be admitted.

In the U.S.A. public opinion appears to find it difficult to accept the form of monopoly in patents which is there known as a "Trust," where a number of firms may combine together with the deliberate object of controlling, first, the sources of supply, and then the market price of a given commodity. Strictly speaking, such associations in our own country would be in defiance of the common law, which renders void any agreement in restraint of trade except in so far as that agreement is necessary for the protection of the parties concerned in pursuing their lawful occupations.

In the U.S.A. the menace of the Trust has led to the passing of a series of anti-Trust statutes such as the Sherman and Clayton Acts. These Acts do not seem to have satisfied public opinion as far as the wireless industry is concerned, for within the last few weeks further Bills have been presented to the House of Representatives with the object of strengthening the operation of the existing laws in cases where any Trust or "unlawful association" is based upon the possession of patent rights. One of the clauses of the proposed Bill provides that it shall be a complete defence to any suit for an infringement of patents if it could be shown that the plaintiff in such suit is using or controlling his patent in violation of any law against restraint of trade, that is to say, if he is a member of any "illegal Trust."

Another clause in the proposed Bill lays down that where the defendant to a suit for infringement pleads the above defence, then this issue would be tried separately and judgment issued thereon before the main suit for infringement can proceed.

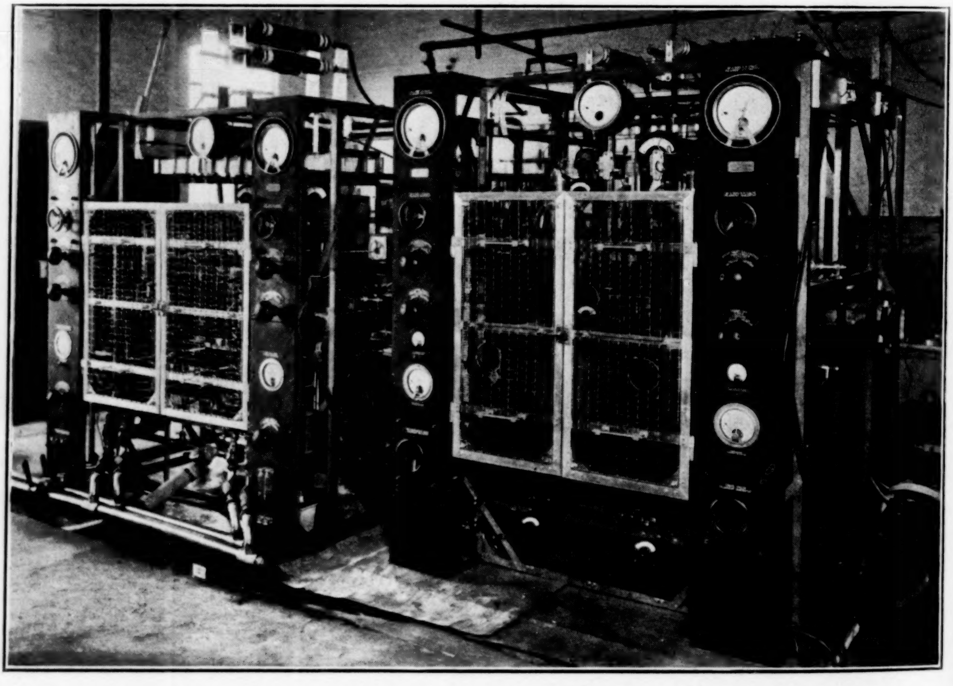
As an interesting illustration of the attitude towards patent monopolies in the States, it may be mentioned that a petition was presented on the 14th May last by the Attorney-General of the United States for the abolition of the Radio Trust (comprising the Radio Corporation of America, the

General Electric Company, the American Telephone and Telegraph Company, the Western Electric Company, and six other radio firms). In this petition it is set out *inter alia* that the defendants have enjoyed an exclusive community of interest in each and all of the patents owned by the group of firms in question in order that they should not compete with each other, and it is argued that with this object in view they have continuously refused, except on terms prescribed by themselves, to grant licences to any other firms. Further, that the Trust have acquired or controlled no fewer than 4,000 patents, thus forming a " pool " which gives them the power to dictate, in agreement amongst themselves, the terms upon which they will permit other parties to engage in the radio industry. It is also argued that the situation which they have thus created for themselves enables them to exact heavy royalties and to impose burdensome conditions upon any who may apply to them for licences.

In the petition the request is made that all the defendants be perpetually restrained from continuing their associations, and that all contracts made between them may be declared null and void.

This attitude towards radio monopoly is attracting the close attention of all sections of the radio industry in the United States, and it is not without interest in our own country, where it may provide a useful object-lesson should a similar situation ever arise here.

The Short-wave Transmitter 5 SW at Chelmsford.



A photograph of 5SW, the short-wave station built by Marconi's Wireless Telegraph Company, Ltd., and used by the B.B.C. for experimental Empire Broadcasting transmissions.

At the recent Colonial Office Conference agreement was reached on the subject of the erection of a permanent Empire Broadcasting station, and a scheme was approved for the establishment of a service at an annual cost estimated at £22,000. It is probable that the station will be erected near Daventry.

Moving Coil Loud Speakers.[*]

By H. M. Clarke, B.Sc.

IN the July, 1929, number of EXPERIMENTAL WIRELESS AND THE WIRELESS ENGINEER, there appeared an article by Mr. C. R. Cosens developing formulæ for the behaviour of the moving coil loud speaker, and in another article of the same issue there were some experimental curves of the performance of a particular instrument constructed and tested by the present writer.

Mr. Cosens gave a table of figures predicting the performance of an instrument having certain dimensions and operating under certain conditions, and it may interest readers to see how far these figures agree with experimental results.

The principal difference is that the former show input and the latter output. It is also necessary to note what differences there are between the experimental conditions and those assumed in the predicted behaviour.

There are three differences between the experimental conditions and the conditions of operation assumed by Mr. Cosens.

First, there is a resonant frequency in the experimental conditions. Secondly, the theory does not take account of friction and suspension losses and change of iron loss due to motion, all of which are usually present in normal working conditions. Thirdly, the theory does not allow for a change in reactance due to motion, which is not strictly an output but which is measured in the input curves shown.

With regard to the first, the theory can be amended to suit the particular case, as Mr. Cosens points out. The second is minimised in the present case since there is practically no iron loss in this instrument. The mechanical losses, however, remain. The third effect will be considered later.

The first thing is to include cases of resonance.

Using Mr. Cosens' notation, let

γ be the total length of wire in the moving coil,
B the flux density in the air gap,
β the damping coefficient in dynes/cm./second,
h the restoring force of the suspension in dynes/cm.,
S the radiation resistance in absolute units,
m_0 the mass of moving system in grammes,
$\triangle m$ the added mass due to air inertia in grammes,
f the frequency,
ω equal $2\pi f$.

Then $m = m_0 + \triangle m$ is the effective mass of the moving system in grammes.

Mr. Cosens shows that

$$S = \frac{\gamma^2 B^2}{\beta(1 + \omega^2\tau^2)}$$

where
$$\tau = \frac{m - \dfrac{h}{\omega^2}}{\beta}$$

When there is no resonant point within or near the range of working frequencies $\tau = \dfrac{m}{\beta}$ approximately, and the tables on p. 362 are calculated on this assumption.

Consider a case of resonance when $\omega = \omega_s$ and distinguish the symbols for that frequency by the suffix " S."

Then $\omega_s = \sqrt{\dfrac{h_s}{m_s}}$, and if m_s and ω_s are known, h_s can be calculated.

Assuming h to be constant and equal to h_s, which is justified if the suspension is not strained beyond the elastic limit, we have

$$\tau = \frac{m - \dfrac{h_s}{\omega^2}}{\beta} = \frac{m - m_s\left(\dfrac{\omega_s}{\omega}\right)^2}{\beta};$$

and $S = \dfrac{\gamma^2 . B^2}{\beta(1 + \omega^2\tau^2)}$ can be calculated for the resonant case.

S is the motional resistance and $\omega\tau S$ the motional reactance in absolute units, the latter being inductive if negative and capacitive if positive. If they are divided by 10^9, they become ohms. The figures given in Table I show these quantities for an instrument having the following dimensions and from which the curves on pages 381, 382 were obtained.

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[*] MS. first submitted to the Editor September, 1929, and in final form June, 1930.

Turns of wire on moving coil ..	1,400
Length of mean turn	16.5 cms.
Flux density in air gap B ..	4,160
Radius (C) of cone diaphragm	11.5 cms.
Mass of coil and diaphragm (m_o)	25 grammes

Hence $\gamma^2 B^2 = 9.23 \times 10^6$.

From curve on page 382

$$f_s = 1230$$
$$\omega_s = 7725$$

From Table I

$$\triangle m_s = 1.2$$

Therefore $m_s = m_o + \triangle m_s = 26.2$

and $h = h_s = 26.2 \times 7725^2$

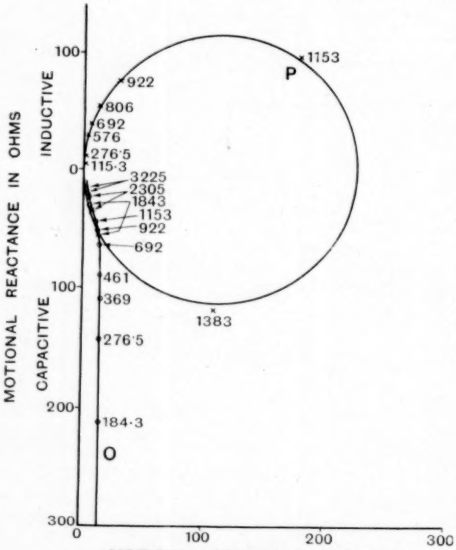

Fig. I.—*O, theoretical curve without resonance; P, theoretical curve with resonance at* 1230 *frequency.*

Table I also gives figures for S and $\omega\tau S$ in ohms for the same instrument ignoring resonance (see curve O, Fig. I). In Fig. I, S and $\omega\tau S$ are plotted vectorially to show motional impedance P and in Fig. 2 the experimental curve F is reproduced for convenience of comparison. The theoretical motional impedance becomes a pure resistance at resonance since τ vanishes. The practical motional impedance, however, is not a pure resistance at resonance.

This phenomenon is noticed by A. E. Kennelly in the ordinary telephone with iron diaphragm, and is shown by the compensated as well as by the uncompensated moving coil instruments, as will be seen if the motional impedance curves on pages 381, 382 be compared.

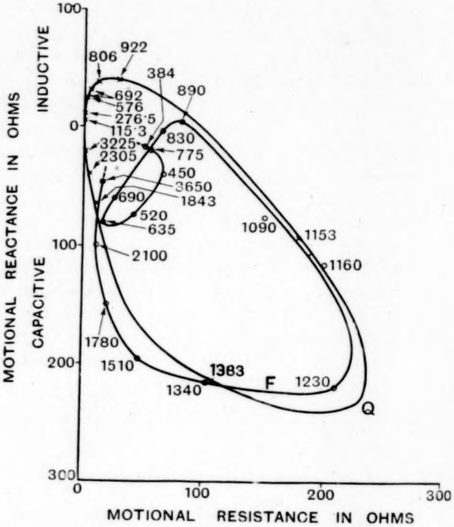

Fig. 2.—*F, experimental curve; Q, theoretical curve resonating at* 1230, *with* $\triangle L$ *correction.*

In the case of the attracted iron telephone, the working flux is not in phase with the working current, the displacement being caused by the iron losses and reactance of the eddy currents in the diaphragm. Consequently, the velocity vector of motion, which is in phase with the working flux, is displaced from the current. Hence it follows that at resonance the true motional impedance, consisting as it does of pure resistance, is not in phase with the working current. A similar effect is produced in the moving coil instrument, as can be seen from the curves.

E. Mallett * suggests that the effects of the iron losses and iron reactance can be considered as due to a closed secondary circuit magnetically linked with the main circuit and having constants to suit the conditions.

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* E. Mallett, *Telegraphy and Telephony*, p. 151 *et seq*.

There is, however, this fundamental difference between the attracted iron and the moving coil telephone, namely, that the alternating field produced by the signal current is necessary to produce motion in the former case, but is not necessary in the latter. In the former, the eddy current field has an effect upon the variation of magnetic flux which produces the motion; in the latter the eddy current flux is located in space in such a way as to have no effect upon the effective driving flux in the air-gap. Keeping this in mind, it can be shown that Professor Mallett's modification can be taken as equivalent to an increase of the impedance of the instrument, but no change in the velocity of motion. The increase in the impedance of the instrument is vectorial and is measured in the input curves usually called motional impedance. Therefore such curves are not solely due to physical motion of the diaphragm, but contain resistance and reactance terms which can be attributed to the closed secondary circuit representing eddy current effects.

If the impedance of such a circuit be Z_2, and if the mutual magnetic coupling between it and the main circuit be M, then Professor Mallett's correction can be shown to be equal to an increase of impedance of $\dfrac{\omega^2M^2}{Z_2}$ vectorially. The impedance Z_2 of the closed secondary will in this case represent the change in the eddy current circuit constants and will be complex, consisting of a resistance and a reactance component. This means that $\dfrac{\omega^2M^2}{Z_2}$ will be complex, the components depending on the characteristics of the eddy current circuit. These characteristics vary with frequency, since the iron losses vary in that way also. Since the variation of the motional impedance is therefore complex, it is unlikely that it ever has a pure resistance value, and still less likely that such a value would occur at resonance. The changes of this added impedance, due to eddy current changes, depend not only on the magnetic configuration and materials of the instrument, but also upon frequency and amplitude of motion of the main coil and probably upon the phase of the working current with respect to the motion. The whole problem has many variables, which are different for the different instruments which can be produced. Suffice it to say that the ideal motional impedance circle with its centre on the resistance axis becomes displaced in such a way that its centre is brought into a capacitive position, since $\dfrac{\omega^2M^2}{Z_2}$ is a capacitive impedance if Z_2 is inductive. Moreover, it is distorted from the circular form due to the changes in eddy current losses, such changes being apparently a maximum at the comparatively large amplitudes of displacement in the neighbourhood of resonance.

TABLE I.

						No resonance.			Resonant Frequency 1230.				
r	f Cycles per Second.	ω	β	Δm grams.	m grams.	τ $\times 10^{-4}$	S ohms.	$\omega\tau S$ ohms.	τ $\times 10^{-4}$	S ohms.	$\omega\tau S$ ohms.	ΔL ohms.	$\omega\tau S+\Delta L$ ohms.
0.3	69.2	435	400	10.43	35.43	886	14.55	459	−206,500	0.000627	−2.4	0.000475	−2.4
0.5	115.3	725	1,104	10.3	35.3	319.5	14.5	337	− 26,700	0.00207	−4.01	0.0221	−3.99
0.8	184.3	1,158	2,780	10.05	35.05	126.0	14.5	212	− 4,070	0.015	−7.06	0.60	−6.96
1.2	276.5	1,736	6,050	9.52	34.52	57.0	14.45	142.5	−828	0.075	−10.77	0.334	−10.44
1.6	369	2,317	10,270	8.82	33.82	32.65	14.45	109	−251	0.267	−15.53	0.89	−14.64
2.0	461	2,895	15,120	8.0	33.0	21.8	14.0	88.5	−101.3	0.71	−20.85	1.89	−18.96
2.5	576	3,620	21,500	6.83	31.83	14.8	13.5	72.2	−40.5	2.0	−29.3	4.27	−25.03
3.0	692	4,345	27,630	5.59	30.59	11.07	12.95	62.2	−19.0	4.85	−40.0	8.63	−31.37
3.5	806	5,065	32,900	4.39	29.39	8.93	12.2	55.1	−9.58	11.48	−55.75	16.0	−39.75
4.0	922	5,785	36,860	3.3	28.3	7.67	11.28	50.1	−4.95	27.2	−78.0	36.3	−41.7
5.0	1,153	7,250	40,350	1.596	26.596	6.59	8.95	42.7	−0.744	178	−96.0	190	+94.0
6.0	1,383	8,690	39,000	0.653	25.65	6.57	6.57	37.5	+1.26	108	+118	96	+214.0
8.0	1,843	11,580	33,600	0.38	25.38	7.55	3.31	29.0	+4.09	11.65	+55.3	7.75	+63.05
10.0	2,305	14,490	35,350	0.441	25.44	7.2	2.225	23.2	+5.1	4.72	+34.8	2.52	+37.32
12.0	2,765	17,360	37,000	0.1975	25.2	6.815	1.653	19.6	+5.4	2.82	+26.4	1.255	+27.65
14.0	3,225	20,270	35,050	0.1215	25.12	7.16	1.158	16.8	+6.09	1.72	+21.2	0.657	+21.86
16.0	3,690	23,170	35,700	0.152	25.15	7.045	0.9	14.7	+6.23	1.24	+17.9	0.414	+18.31

Curve *Q*, Fig. 2, is an attempt to arrive at the practical case by adding an empirical correction to the theoretical case. The Table 1 shows a quantity $\triangle L = \frac{\omega_s}{\omega} \times S$, which is added to $\omega\tau S$ to produce the reactive component used in plotting Q. Q is remarkably close to the practical curve F.

Summarising, the author wishes to point out that the input motional impedance does not measure merely the electrical loading of the system due to atmospheric and diaphragm loading, but includes changes in the electrical losses of the instrument. In conclusion, it would seem necessary to determine the vector velocity of the moving system by a method which is not vitiated by such changes and to compare the motional vector impedance thus obtained with that shown by such curves as F and P. In this way, some knowledge may be gained as to the way in which the eddy current secondary circuit affects the problem.

A Note on an Alternative Equivalent Circuit for the Thermionic Valve.*

By N. R. Bligh, B.Sc. (Eng.).

THIS note is to point out the advantages of an alternative equivalent circuit for the thermionic valve and the general application of this circuit, of which a particular application has been given by Butterworth (*E.W. & W.E.*, June, 1929).

It can be shown that any constant voltage generator of voltage E having an internal series resistance R is equivalent to a constant current generator of current E/R with an internal shunt resistance R.

The classic derivation of an equivalent circuit for the anode circuit of a valve (Nichols—*Physical Review*, Vol. 13, p. 411) consists of a voltage me in series with a resistance ρ, where m is the amplification factor of the valve, e is the applied grid voltage and ρ is the a.c. resistance of the valve.

Thus, accepting this equivalent circuit, another can be obtained consisting of a constant current generator of current ke with a shunt resistance ρ where $k = m/\rho$ is the mutual conductance of the valve.

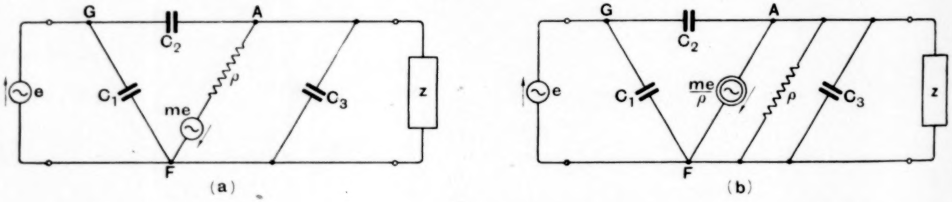

Fig. 1.

The valve capacities fall as usual between the points representing the grid, anode and filament of the valve and the two equivalent circuits are shown in Fig. 1 where the ~, enclosed in two circles, represents a constant current generator.

The great advantage of the method of representation shown in Fig. 1 (b) is that all the external impedances in the anode circuit are thrown in parallel with ρ and C_3 and the combination of series and shunt impedances is avoided. If all the impedances are expressed as admittances the case becomes still simpler.

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* Manuscript first received 25th January, 1930.

In August, 1928, the MS. of an article entitled "Reaction and Oscillation in Valve Circuits" was submitted to us by Mr. W. S. Percival. This was not published in *E.W. & W.E.* and we do not know if it has been published elsewhere, but the basic idea of the article was the same as that adopted by Mr. Bligh, viz., the replacement of the constant e.m.f. generator and series resistance by a constant current generator and shunt resistance in the consideration of valve problems.—EDITOR.

The author has since discovered that a similar treatment of the valve circuit was published by Mayer in *Teleg. und Fernspr. Tech.*, November, 1926.

For instance, in the case of a resistance coupled amplifier, the anode and grid coupling resistances and the valve resistance can all be considered in parallel over the range where the reactance of the coupling condenser is small. Thus it can be seen that it is advantageous to use a valve of high a.c. resistance, consistent with a good mutual conductance, since coupling impedances are generally limited from the point of view of frequency characteristic.

Another example is afforded by the use of a tuned circuit as the coupling impedance. Using the constant current circuit the effect of the shunt resistance ρ on the resonance curve can easily be seen and for greatest selectivity ρ should be large.

The input impedance of a valve can easily be obtained using this circuit. If we call the impedance other than that due to the grid filament capacity the *Additional Input Impedance* this can be evaluated using the circuit of Fig. 2.

The vector impedance of the grid anode capacity is shown as a, the vector impedance of the anode filament capacity and ρ in parallel as b, and z is the external load.

Then from Fig. 2 since e is equal to the sum of the voltages across a and across b and z in parallel

$$e = ai_1 + i_2 \frac{bz}{b + z}$$

and since the sum of the currents arriving at A is zero we have—

$$i_1 - i_2 - ke = 0$$

Therefore,

$$i_1 = e\frac{z(1 + bk) + b}{z(a + b) + ab}$$

and thus the Additional Input Impedance

$$= e/i_1 = \frac{z(a + b) + ab}{z(1 + bk) + b}.$$

The voltage amplification may be obtained by considering the combined impedance of b and z together with the current i_2 flowing into them.

$$\text{Thus} \quad i_2 = e\frac{(1 - ak)(b + z)}{z(a + b) + ab}.$$

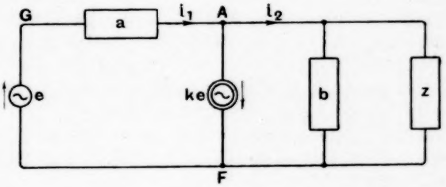

Fig. 2.

The voltage across $z = \frac{i_2 zb}{z + b}$ and the magnification is given by $\frac{z(1 - ak)b}{z(a + b) + ab}$.

Frequency Modulation and Distortion.*

By T. L. Eckersley.

THOSE who, like myself, have attempted to establish radiotelephonic communication on short waves, without taking adequate precaution to prevent any frequency modulation, will know, only too well, the almost devastating distortion to which such transmissions are subject, even over relatively short distances. This note is written with the object of offering some explanation of the effects observed.

A disconcerting feature which may lead one to fail to suspect one's transmitter is that it gives, in general, good, if not perfect, quality locally, that is to say, within a few hundred metres from the transmitter.

Nevertheless, there is evidence that the main cause of such distortion is a frequency modulation varying with the amplitude of the oscillation.

In general, if the transmitting set is not controlled by a master oscillator, and if special precautions are not taken, the oscillation frequency will depend to a greater or less extent on the anode voltage. As this varies in unison with the speech intensity, so will the frequency vary, and we have, as a rule, a partially amplitude-modulated and partially frequency-modulated oscillation.

For simplicity, consider a single modulation frequency f_2 and let f_1 be the frequency of the carrier.

Then the appropriate expression for a frequency modulated oscillation is

$$A \cos\{pt + K_1\phi(t)\} \quad \ldots \quad \ldots \quad (1)$$

where $p = 2\pi f_1$, and $\phi(t)$ is a periodic function of t, having as its period the modulation frequency f_2.

It is not correct to substitute for p a variable quantity $2\pi(f_1 + \delta f \sin 2\pi f_2 t)$ say, for our function would then be of the form

$$(a) \sin 2\pi(f_1 + \delta f \sin 2\pi f_2 t)t,$$

instead of

$$(b) \sin 2\pi(f_1 t + \delta f \sin 2\pi f_2 t)$$

(where for simplicity $\delta f \sin 2\pi f_2 t$ is substituted for $K_1\phi(t)$).

The correct expression for the frequency is the rate of change of the phase of a periodic function.

In the case (a) this is:

$$(a')\ \frac{d}{dt} 2\pi(f_1 + \delta f \sin 2\pi f_2 t)t = 2\pi(f_1 + \delta f \sin 2\pi f_2 t + \delta f \,.\, 2\pi \,.\, f_2 \times t \cos 2\pi f_2 t)$$

and in the case (b)

$$(b')\ \frac{d}{dt} 2\pi(f_1 t + \delta f \sin 2\pi f_2 t) = 2\pi(f_1 + \delta f \,.\, 2\pi f_2 \cos 2\pi f_2 t)$$

The last term on the right-hand side of (a'), which is proportional to t and $\cos 2\pi f_2 t$, sweeps over a wider and wider amplitude as t increases, and the expression cannot therefore represent a uniformly modulated frequency modulation. The expression (b') gives a frequency varying periodically between constant limits, *i.e.*, $f_1 + 2\pi\delta f \,.\, f_2$ and $f_1 - 2\pi\delta f . f_2$ and expresses a uniform frequency modulation correctly.

For simplicity and shortness we may put $\sin qt$ for $\phi(t)$ in (1) where $q = 2\pi f_2$, then the frequency will range between the limits $\frac{1}{2\pi}(p \pm K_1 q)$.

When the oscillation is amplitude-modulated as well as frequency-modulated we can modify the expression (1) to the form

$$(1 + K_2 \cos qt) \cos (pt + K_1 \cos(qt + \phi)) \quad (2)$$

This can be expanded in the usual way to

$$(\cos (pt + K_1) \cos (qt + \phi))$$
$$\left.\begin{array}{l} + \frac{1}{2}K_2 \cos \{(p + q)t + K_1 \cos (qt + \phi)\} \\ + \frac{1}{2}K_2 \cos \{(p - q)t + K_1 \cos (qt + \phi)\} \end{array}\right\} (3)$$

The former represents the carrier wave and the latter the two side waves, which are at least as real as mathematics and printers' ink can make them.

Each of these waves is, however, not of constant frequency. The range of frequency change on each is $\frac{K_1 q}{2\pi}$. We can represent this graphically in Fig. 1, where the ordinates represent the amplitudes and the abscissæ the frequencies.

On account of the frequency variation the whole group consisting of carrier and side waves together moves to and fro along the frequency axis, but it will be noticed that the *difference*-frequencies between carrier and side waves, which are those reproduced in reception, remain constant. Consequently when such an oscillation is detected locally on a receiver that has a sufficiently wide band of reception to cover the whole amplitude of the frequency variation, no distortion will be heard, and the telephony will be perfect. What then is it that introduces the distortion in working over any distances more than a few miles ? I think there can be no doubt that it depends in some way upon the nature of short wave transmission as modified by the reflections from the Heaviside layer. Now many experiments have shown that in the range of wavelengths between 30 and 100 m. the wave reflected from the Heaviside layer may be as strong or even stronger than the direct ray even at a few km. distance, but the reflected ray has to travel a distance which is probably of the order of 450 km. further than the direct ray and will arrive some 1.5 milliseconds later.

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* MS. received by Editor, May, 1930.

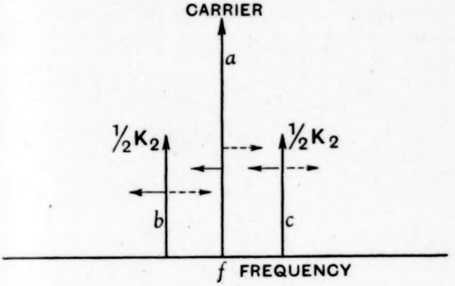

Fig. 1.

At greater distances, for example, say 200 km., with a 60 m. wave, there may be as many as four ricochets between the earth and the Heaviside layer, the last signal arriving some six milliseconds after the first.

It is these delayed echoes that play havoc with the quality. It is easy to understand their effect even without the aid of mathematics. Thus in Fig. 1, let a, b, c, be the mean frequencies of the carrier and two side waves. Then the actual frequencies of the carrier and side waves at or near the transmitter oscillate about these mean positions at a frequency f_2.

Suppose now at the instant $t = 0$ they are at their mean position, and to fix one's ideas let f be increasing. If the receiver at R is at a distance d away from the transmitter, then at a time d/c the received side waves are at their mean position (c = velocity of light). But at the same instant R is receiving signals by the long path d_1 which were emitted at a time $(d - d_1)\ c$, at which time the carrier and side bands might be at any other position within the frequency variation band. Thus we have a, a_1, a_2 (Fig. 2), the carrier and side waves of the direct ray, moving to the right, and for example b, b_1, b_2 the carrier and side wave of the reflected wave, moving to the left.

The two sets of carrier and side waves are scissoring across each other, and not only are the normal beat tones, between a and a_1, a and a_2 and between b and b_1, b and b_2 present, but there are other beat tones $a\ b$, $a\ b_1$, $b_2\ a$, etc., which bear no relation to the true modulation frequency but are varying with a rapidity depending upon the amplitude of the frequency excursion on either side of the mean. It will easily be seen that this results in most appalling distortion, and renders futile any attempt to use even pure frequency modulation in any transmission where appreciable echo delays (of the order of 2 or 3 milliseconds) are present. This excludes practically the whole short wave range, for facsimile experiments have shown the existence of multiple signals or echoes on all such wavelengths. We may express these ideas perhaps more precisely as follows :

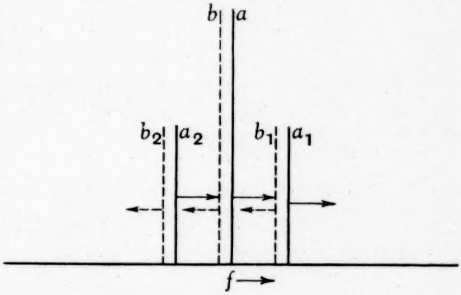

Fig. 2.

The received signal will consist of the sum of two or more signals by the direct and reflected paths. We may express this in the form:

Direct ray

1. $A_1 \cos\{pt + K_1 \cos(qt + \phi)\}$

1_a, $\frac{1}{2}A_1K_2 \cos\{(p + q)t + K_1 \cos(qt + \phi)\}$

1_b, $\frac{1}{2}A_1K_2 \cos\{(p - q)t + K_1 \cos(qt + \phi)\}$

Reflected ray

2. $A_2 \cos\{p(t + \tau) + K_1 \cos(qt + \tau) + \phi\}$

2_a, $\frac{1}{2}A_2K_2 \cos[(p + q)(t + \tau) + K_1 \cos\{q(t + \tau) + \phi\}]$

2_b, $\frac{1}{2}A_2K_2 \cos[(p - q)(t + \tau) + K_1 \cos\{q(t + \tau) + \phi\}]$ .. .. (4)

The beat tones between 1 and 1_a, 1 and 1_b, 2 and 2_a, 2 and 2_b, which give the undistorted tone in the receiver, are not the only ones present. In addition, there are the distortion beat tones between

1 and 2.

1, 2_a and 2_b.

2, 1_a and 1_b.

The beat tones formed from the combination of, for example, 1 and 2, represent a note of frequency

$$\frac{1}{2\pi}\frac{d}{dt}\{K_1 \cos(qt + \phi) - K_1 \cos(q(t + \tau) + \phi)\}$$

$$= K_1 \frac{q}{2\pi}\sqrt{2}(1 - \cos q\tau)^{\frac{1}{2}} \sin(qt + \phi + y)$$

where

$$\tan y = \sin q\tau/(\cos q\tau - 1) \quad .. \quad (5)$$

The combination tones $(1, 2_a)$ or $(2, 1_a)$ are $\cos\{qt + K_1 \cos(qt + \phi) - K_1 \cos(q(t + \tau) + \phi)\}$ which represents a beat frequency of

$$\frac{q}{2\pi} - K_1 \frac{q}{2\pi}\sqrt{2}(1 - \cos q\tau)^{\frac{1}{2}} \sin(qt + \phi + y)$$

a frequency which swings between

$$\frac{1}{2\pi}q\{1 + K_1\sqrt{2}\sqrt{1 - \cos q\tau}\}$$

and $$\frac{q}{2\pi}\{1 - K_1\sqrt{2}\sqrt{1 - \cos q\tau}\} \quad .. \quad (6)$$

and constitutes a very complete distortion.

It appears from the above expression that $\cos q\tau$ must differ appreciably from unity if distortion is to be effective. This implies that τ, the echo delay, must be comparable with the time period T of the modulation. Since τ may be anything up to 5 or 6 milliseconds, say, $\frac{1}{200}$ sec., the distortion will be appreciable on all frequencies from at least 100 cycles upwards.

From the formula (6) we can estimate the maximum allowable amount of frequency modulation if distortion from this cause is to be avoided.

It is quite clear that if $K_1 = 0$ the distortion is zero, but so long as $K_1 << 1$, the distortion will be small. Now $2\pi K_1$ is the deviation of the phase of the carrier during a period of the modulation frequency f_2 from its true value, *i.e.*, for zero frequency modulation. For if ϕ is this phase

$$\frac{d\phi}{dt} = 2\pi f_1 \pm 2\pi f_2 K_1 = \frac{2\pi}{\tau_1} \pm \frac{2\pi}{\tau_2} K_1$$

where τ_1 is the time period of the carrier, τ_2 is the time period of the modulation, and $\left(\frac{d\phi}{dt}\tau_2\right) = \delta\phi$ is the change of ϕ per cycle of modulation

$$= \frac{2\pi\tau_2}{\tau_1} \pm 2\pi K_1$$

i.e., $$\pm 2\pi K_1 = \delta\phi - \frac{2\pi\tau_2}{\tau_1}$$

Now $\frac{2\pi\tau_2}{\tau_1}$ is what the phase ϕ would have been without frequency modulation, therefore $\delta\phi =$ deviation phase from its true value, *i.e.*, δ say

δ must be small compared with 360 deg., less than 36 deg. for 10 per cent. variation of f_2.

Frequency modulation, as far as I am aware, is the worst form of distortion in Radio Telephony. The importance of keeping the frequency steady was recognised by Capt. Round as long ago as the earliest days of broadcasting.

Experimental comparisons of crystal driven and undriven sets show conclusively that if frequency modulation is overcome distortion disappears, and it therefore seems probable that the above explanation is essentially correct.

Capacitative and Inductive Coupling, Including a Method of Measuring Mutual Inductance at Radio Frequencies.*

By Raymond M. Wilmotte, B.A., A.M.I.E.E.

1. Introduction.

THE terms capacitative and inductive coupling are generally applied in a vague manner as representative of two different types of electrical reaction between two circuits. When the reaction takes place through lines of electric force, it is called capacitative, and when this reaction occurs by means of magnetic lines of force it is inductive.

In the case of capacitative coupling there must be displacement currents flowing from one circuit to the other; that is to say, tubes of electric force start at one circuit and end on the other. Where each of these tubes ends, there must be a change in the conduction current at that point equal to the dielectric displacement current represented by the tube. The net result is that current appears to flow from one circuit to the other. This is so, because the algebraic sum of the currents entering and leaving a point (or more correctly a closed surface) is always zero. The word current, in this instance, is meant to include the dielectric displacement current as well as the ordinary conduction current caused by an actual flow of free electric charges, as occurs in conductors (see a previous article by the author entitled " Some Fundamental Definitions," *E.W. & W.E.*, 1928, pp. 607–615).

The case of inductive coupling is very similar. The lines of electric force produced by the current in the first circuit, instead of flowing from one circuit to the other, flow from one point to another of the second circuit. This is represented as an E.M.F. induced in the second circuit from the first.

In a circuit diagram capacitative coupling is, therefore, represented by suitable capacities joining various points of two circuits, while inductive coupling is represented by a mutual inductance or its equivalent.

It is generally accepted that the two kinds of couplings are very similar, but how similar or, alternatively, how they differ, is not usually explained. It will be shown below that one kind of coupling can be replaced by the other, and by using the usual circuital representations of these circuits (*i.e.*, capacities and mutual inductances) formulæ can be obtained for the transformation of one into the other.

In order to develop this matter, the meaning of the " impurity " of a mutual inductance must be explained.

Using sinusoidal alternating currents, the symbolic representation of a coefficient of mutual induction M is the operator $jM\omega$ (where $j = \sqrt{-1}$ and ω is 2π times the frequency). This means that the E.M.F., E, induced in the second circuit by the current I in the first is given by

$$E = jM\omega I \qquad \ldots \quad \ldots \quad \ldots \quad (1)$$

In other words, the current I is in quadrature with and lags behind the E.M.F., E.†

In actual practice, owing to capacity effects, eddy currents, dielectric losses, and, to a very small extent, electromagnetic

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*MS. received by Editor, November, 1928.

† This is, of course, the reverse of the usual convention. In the case of self-induction the induced E.M.F. opposes the current when the latter is increasing, and is in the same direction as the current when the latter is decreasing; this necessitates the minus sign in the formula $e = -L di/dt$, and when the current is sinusoidal, the induced E.M.F. necessarily lags 90° behind the current. In the case of two separate circuits it is customary to write $e_2 = -M di_1/dt$, from which it follows that the induced E.M.F. lags 90° behind the current. To realise the inconvenience of the convention adopted by the author, one has only to consider the case of two single-turn coils side by side; whichever direction is taken as positive in one coil, the opposite direction must be taken as positive in the other, unless one makes the further assumption that the mutual induction between two such coils is negative. This the author does, with the result that if the self-inductance of the two parts of a solenoid are L_1 and L_2, he obtains $L = L_1 + L_2 - 2M$ for the total inductance instead of the conventional $L_1 + L_2 + 2M$.—EDITOR.

radiation, the current I, and the E.M.F., E, are not accurately in quadrature. When this is so, the mutual inductance is said to be impure and the impurity is defined by a quantity σ such that the operator of mutual induction instead of being $jM\omega$ is now $(\sigma + jM\omega)I$. Equation (1), therefore, becomes

$$E = (\sigma + jM\omega)I \qquad .. \qquad .. \qquad (2)$$

In the same way a capacity coupling may not be truly represented by a simple condenser connecting one point on each of the circuits. There may be losses in this condenser. This is often represented by a shunting resistance across the condenser and this shunting resistance corresponds to the impurity of a mutual inductance.

One might reasonably expect that a pure mutual inductance could be represented by a pure capacity coupling, but this is not so. The relation between the two types depends on the constants of the two circuits that are coupled together.

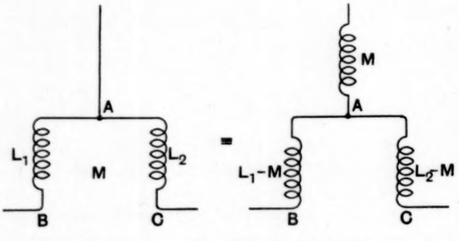

Fig. 1.—*Transformation of a mutual inductance.*

2. Some Transformations.

We shall employ a well-known and extremely useful transformation, by which a mutual inductance can be represented by a self-inductance common to the two circuits.

This is shown in Fig. 1, which is self-explanatory. It should be noticed that the mutual induction M, which can, of course, be either positive or negative, becomes common to both circuits and is connected to what corresponds to the common point of the two coils of the mutual inductance. In fact, this representation can only be applied when two points on the two circuits are connected together. There may be impedances between this common point and the mutual inductance as shown in Fig. 2, but there must not be any current flowing in or out within these impedances. That is, there must be no other connections between the points A and D or A and E to other parts of the circuit.

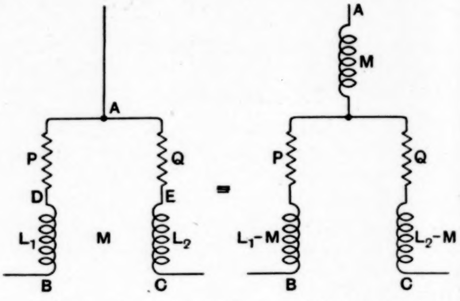

Fig. 2.—*More general transformation of a mutual inductance.*

When the mutual inductance is impure and the value of the impurity is σ, it can also be represented by an equivalent circuit as shown in Fig. 3.

The impurity σ possesses certain properties very similar to those of the mutual inductance. Just as the value M of the mutual inductance can never be greater than the sum of the values of the self-inductances $(L_1 + L_2)$ of the coils forming it, so the impurity σ can never be greater than the sum of the effective resistances $(R_1 + R_2)$ of the two coils. Just as M^2 is always less than the product $L_1 L_2$, so σ^2 is always less than $R_1 R_2$.

We shall also use another transformation due to G. A. Campbell ("Cisoidal Oscillations," *Trans. Am.I.E.E.*, 1911, Vol. 30, p. 891) and developed by S. Butterworth ("Capacity and Eddy Current Effects in Inductometers," *Proc. Phys. Soc.*, London, 1921, Vol. 30, p. 134). This is a transformation of a star to a mesh network as shown

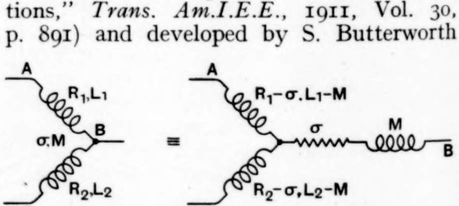

Fig. 3.—*Impurity in a mutual inductance.*

in Fig. 4. If a, b, c are the impedances forming a star network, joining the point O to the points A, B, and C, respectively, and X, Y, Z those of an equivalent mesh network joining A to B, B to C, and C to A, the relation between these quantities is

$$a = \frac{YZ}{X + Y + Z} \quad \cdots \quad \cdots \quad (3)$$

$$b = \frac{ZX}{X + Y + Z} \quad \cdots \quad \cdots \quad (4)$$

$$c = \frac{XY}{X + Y + Z} \quad \cdots \quad \cdots \quad (5)$$

also

$$X = \frac{ab + bc + ca}{a} \quad \cdots \quad \cdots \quad (6)$$

$$Y = \frac{ab + bc + ca}{b} \quad \cdots \quad \cdots \quad (7)$$

$$Z = \frac{ab + bc + ca}{c} \quad \cdots \quad \cdots \quad (8)$$

These equations hold so long as current is only taken out at the points A, B and C. a, b, c, X, Y, Z, can be, and usually are, complex numbers.

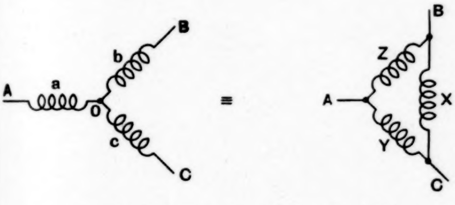

Fig. 4.—*Transformation of star to mesh network.*

This transformation, together with that for mutual inductance, though they cannot alone be applied to solve every circuit, deserve greater use. Most circuits commonly met with can be solved by their judicious application. Moreover, it is usually far less laborious to solve a circuit by these means than by the straightforward symbolic method.

3. Transforming Capacitative to Inductive Coupling and Vice Versa.

For our purpose we are only concerned with replacing an inductive by a capacitative coupling as expressed by Fig. 5. In this figure the impure mutual inductance $(\sigma + jM\omega)$ between two coils connected at one point, having self-inductances L_1 and L_2 and effective resistances R_1 and R_2 respectively, is replaced by a capacity C_0, shunted by a resistance (having a conductance G) connecting the free ends of the coils, and vice versa.

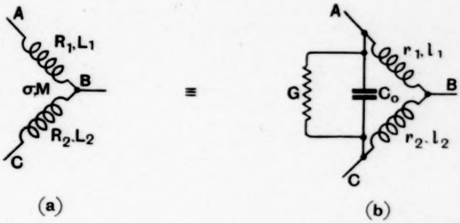

Fig. 5.—*Transformation of inductive to capacitative coupling.*

If the same currents flow in or out at the points A, B and C, and if the two networks are accurately equivalent, some current will flow in the capacity and conductance G of Fig. 5(*b*). The value of the current in the coils A, B cannot, therefore, be the same in the two networks, yet the potential differences between the points A, B and C must be the same.

This can only be overcome by changing the values of R_1, R_2, L_1 and L_2, to r_1, r_2, l_1 and l_2 respectively. The transformation of inductive to capacitative coupling does not, therefore, involve merely a simple change in the type of the coupling, but also a change in the effective impedance of the individual coils.

Taking first the transformation of the inductive to the capacitative coupling, we apply the transformation of mutual inductance (depicted in Fig. 3) and obtain Fig. 6, in which the mutual inductance has been replaced by a resistance σ and a self-inductance M. To this is next applied the star to mesh transformation (depicted in Fig. 4), which directly gives the capacitative coupling of Fig. 5. The formulæ are rather cumbrous, but, if we take R_1, R_2 and σ to be small compared to $L_1\omega$, $L_2\omega$ and $M\omega$ respectively, so that products and squares

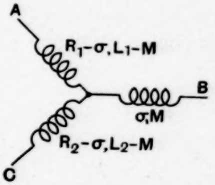

Fig. 6.—*First transformation of Fig.* 5(*a*).

of the small quantities may be neglected, we have

$$C_0 = \frac{M}{(L_1 L_2 - M^2)\omega^2} \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

$$G = \frac{(R_1 L_2 + R_2 L_1)M\omega^2 - \sigma(L_1 L_2 \omega^2 + M^2\omega^2)}{(L_1 L_2 - M^2)^2\omega^4} \quad \ldots \quad \ldots \quad (10)$$

$$l_1 = \frac{L_1 L_2 - M^2}{L_2 - M} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

$$l_2 = \frac{L_1 L_2 - M_2}{L_1 - M} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

$$r_1 = \frac{R_1 L_2 + R_2 L_1 - 2\sigma M}{L_1 - M} - \frac{(R_1 - \sigma)(L_1 L_2 \omega^2 - M^2\omega^2)}{(L_1 - M)^2} \quad \ldots \quad (13)$$

$$r_2 = \frac{R_2 L_1 + R_1 L_2 - 2\sigma M}{L_2 - M} - \frac{(R_2 - \sigma)(L_1 L_2 \omega^2 - M^2\omega^2)}{(L_1 - M)^2} \quad \ldots \quad (14)$$

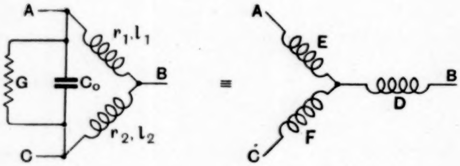

Fig. 7.—*First transformation of capacitative coupling.*

We could solve the inverse problem of transforming from a capacitative to an inductive coupling by solving equations (9) to (14) for M, σ, L_1, L_2, R_1, and R_2. It is simpler, however, to solve the problem directly. First we transform from the mesh to the star network (depicted in Fig. 4) and obtain Fig. 7, in which

$$\begin{aligned} D = &- (r_1 l_2 + r_2 l_1)\, C_0\omega^2 - G l_1 l_2 \\ &- j\omega[l_1 l_2 C_0 \omega^2 - G(r_1 l_2 + r_2 l_1)] \quad \ldots \quad (15) \end{aligned}$$

$$\begin{aligned} E = &\, r_1 - (l_1 + l_2)(r_1 C_0 \omega^2 - G l_1 \omega^2) \\ &\times j\omega[l_1 + (l_1 + l_2) l_1 C_0 \omega^2 - G(2 r_1 l_1 \\ &\quad + r_1 l_2 + r_2 l_2)] \quad \ldots \quad (16) \end{aligned}$$

$$\begin{aligned} F = &\, r_2 - (l_1 + l_2)(r_2 C_0 \omega^2 - G l_2 \omega^2) \\ &+ j\omega[l_2 + (l_1 + l_2) l_2 C_0 \omega^2 \\ &\quad - G(2 r_2 l_2 + r_2 l_1 + r_1 l_2)] \quad \ldots \quad (17) \end{aligned}$$

Applying now the inverse of the transformation for mutual inductance (depicted in Fig. 3), we obtain the inductive coupling of Fig. 6, in which

$$M = - l_1 l_2 C_0 \omega^2 + G(r_1 l_2 + r_2 l_1) \quad \ldots \quad (18)$$

$$\sigma = - (r_1 l_2 + r_2 l_1) C_0 \omega^2 - G l_1 l_2 \omega^2 \quad \ldots \quad (19)$$

$$L_1 = l_1(1 + l_1 C_0 \omega^2) - 2 G r_1 l_1 \quad \ldots \quad \ldots \quad (20)$$

$$L_2 = l_2(1 + l_2 C_0 \omega^2) - 2 G r_2 l_2 \quad \ldots \quad \ldots \quad (21)$$

$$R_1 = r_1(1 + 2 l_1 C_0 \omega^2) + G l_1^2 \omega^2 \quad \ldots \quad (22)$$

$$R_2 = r_2(1 + 2 l_2 C_0 \omega^2) + G l_2^2 \omega^2 \quad \ldots \quad (23)$$

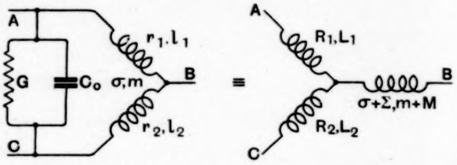

Fig. 8.—*Combination of two types of coupling.*

In these equations terms of the second order of small quantities are neglected. Among these is included $C_0\omega$, which is assumed to be small compared with $1/L_1\omega$ or $1/L_2\omega$.

There is a dangerous pitfall when trying to combine capacitative and inductive coupling. In the transformation used, each type of coupling affects the effective constants of the coils (*i.e.*, it affects the effective values of R_1, R_2, L_1 and L_2).

Thus, if two coils having constants (r_1, l_1 and r_2, l_2) are coupled together by means of a capacity C and conductance G as well as by an impure mutual inductance (σ, m) we might calculate the effective mutual inductance (σ', m'), which is equivalent to the capacity coupling, but this could not be added algebraically to the mutual inductance (σ, m) already present. The transformation of the capacitative coupling will alter the values of (r_1, l_1) and (r_2, l_2) to (r_1', l_1') and (r_2', l_2'), so that whereas (σ', m') would couple two coils (r_1', l_1') and (r_2', l_2'), (σ, m) would couple the coils (r_1, l_1) and (r_2, l_2).

In order to overcome the difficulty, it is necessary to carry out the transformations in a regular sequence. It is possible to transform the inductive coupling as explained in Fig. 3 without altering the value of the capacity C_0 and conductance G. This will alter the effective constants of the coils. l_1, l_2, r_1, r_2 will become ($l_1 - m$), ($l_2 - m$), ($r_1 - \sigma$) and ($r_2 - \sigma$) respectively. It is now possible to apply equations (18) to (23) using these altered constants of the coils. If M, Σ, L_1, L_2, R_1 and R_2 are the values thus obtained, the equivalent system will be as shown in Fig. 8.

If the coupling is small the error introduced by failing to carry out the intermediary transformation will be small, so that in many cases it is possible, to a fair approximation, to add together the effects of the coupling by simple addition.

4. The Sign of the Coupling.

It will be seen from the above equations that a capacitative coupling will oppose an inductive coupling if the mutual inductance is positive, and help it if it is negative. It is therefore necessary to find the convention which has been tacitly assumed regarding the sign of the mutual inductance.* This convention is hidden in the transformation represented in Fig. 9 which has been used previously. It is assumed that the mutual inductance between two coils connected in series is positive if it reduces the self-inductance of the coils. If, therefore, current flows from A to C and no current is taken out of B, the self-inductance between A and B will be less than if there were no mutual inductance if the mutual inductance is positive. If the mutual inductance is negative, the self-inductance will be greater. The same applies to the sign of the impurity, σ. If σ is positive, the effective resistance between A and B will be less than if there were no positive impurity, and vice versa.

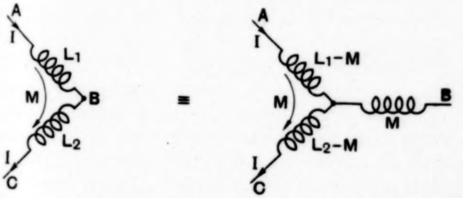

Fig. 9.—*Convention for sign of M.*

It might be noticed that, according to this convention, the mutual inductance between the various parts of an ordinary coil is negative.

5. Measurement of Mutual Inductance and Impurity.

The last paragraph gives the clue to a simple method of measuring the mutual inductance and impurity between two coils. The method has been suggested by L. Hartshorn (*see* " Properties of Mutual Inductance Standards at Telephonic Frequencies," *Proc. Phys. Soc.*, 1926, Vol. 38, p. 312). It consists of measuring the self-inductance and effective resistance of each coil separately. This gives L_1, L_2, R_1, R_2.

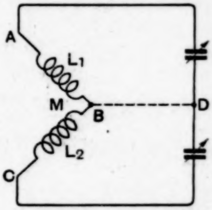

Fig. 10.—*Measurement of mutual inductance.*

The coils are then connected in series in their proper position and the self-inductance and effective resistance of the two coils in series is again measured.

This gives

$$(L_1 + L_2 - 2M)$$

and

$$(R_1 + R_2 - 2\sigma)$$

From these values M and σ can be readily obtained. It should be remembered that both M and σ may be negative. In making the measurements, it may be necessary to take special precautions to keep a given point of the mutual inductance at the desired potential. Usually the common point B is kept at earth potential. To do this, the measurements on each coil separately are made with the point B connected to the screen of the condenser used. When making the measurement with the coils in series two condensers should be used in series with their screens connected together, as shown in Fig. 10. The capacities of the condensers should be so adjusted that joining the point B to the screens of the condensers at D produces no effect on the detecting instrument. In this way it is ensured that the point B is at the same potential as the screens of the condensers. The connexion between B and D should not remain during measurements, as a small change in the potential of B will not appreciably affect the result, while a small current flowing from B to D may do so.

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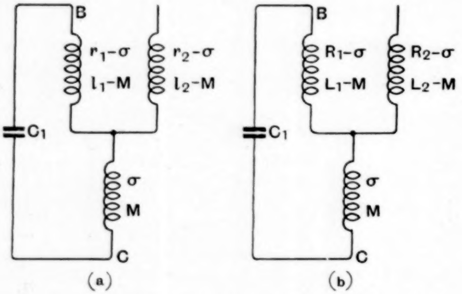
* *See* footnote on p. 485.—EDITOR.

6. Comparison of Inductive and Capacitative Couplings.

Equations (18) to (23) allow us to compare the properties of inductive and capacitative coupling for given conditions.

The first point to note is that inductive and capacitative couplings can only be equivalent at a single frequency. In fact, it can be seen immediately, that for two given coils, the mutual inductance between them, which is equivalent to a capacity across their free ends, is negative and is proportional to the square of the frequency (neglecting the effect of the power factor of the coupling condenser). In other words, if the frequency were doubled, the equivalent mutual inductance would have to be multiplied by four. This means that, with capacitative coupling, the coupling increases as the frequency increases.

This is so if the frequency is varied and the coils remain unaltered. In practice, when the frequency reaches a certain value, the coils will no longer be found suitable and will be altered. As a general rule it can be taken that the coils are chosen so that, as the frequency rises, the reactances are roughly constant. That is, if l_1 and l_2 are the self-inductances of the coils, the values of l_1 and l_2 will be so chosen that $l_1\omega$ and $l_2\omega$ remain approximately constant. When this is so, a given capacity across the free ends of the coils will correspond to a constant mutual inductance between them. This is not the same as a constant coupling, but corresponds to an increase of coupling with frequency.



(a) (b)

Fig. 11.—*Relative properties of* (*a*) *inductive coupling and* (*b*) *capacitative coupling* (*equations* 18 *to* 23).

The superimposition of capacitative and inductive coupling on two coils will give various laws. For instance, the coupling may be adjusted so that at any given frequency the resultant equivalent mutual inductance becomes zero, being positive and negative on either side of this frequency.

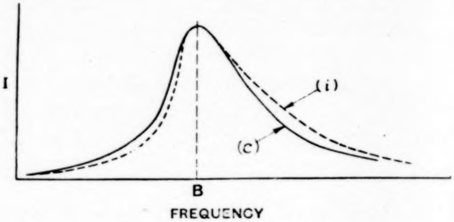


Fig. 12.—*Resonance curves with inductive coupling* (*i*) *and capacitative coupling* (*c*).

The variation of this resultant mutual inductance with frequency will depend on the magnitude of each type of coupling. If the two types of coupling are individually large and oppose one another, so that the resultant coupling is zero at a certain frequency, a small change in the frequency will produce a much larger change in the resultant mutual inductance than if the values of the individual couplings were small. If the couplings help each other, the change in the resultant mutual inductance with frequency will be smaller.

We shall now consider how the type of coupling affects the tuning of the coils.

Consider two coils of self-inductance l_1 and l_2 respectively, and resistance r_1 and r_2. The second coil will be supposed to be connected to a large impedance, such as the grid of a valve, so that the current flowing in it can be considered to have no effective reaction back into the first coil l_1, to which it is coupled. If there is a mutual inductance M between the two coils, the equivalent circuit can be represented by Fig. 11 (*a*), while, if the coupling is produced by a small condenser C joining the free ends of the coils, the equivalent circuit will be represented by Fig. 11 (*b*), in which the constants of the network are given by equations (18) to (23). In both cases the first coil is tuned by means of a capacity C_1.

In the case of inductive coupling the resistance and the self-inductance between the points B and C are r_1 and l_1, while for the capacitative case they are respectively

$$r_1(1 + 2l_1C_0\omega^2) + Gl_1^2\omega^2 \ (= R_1)$$
$$\text{and} \quad l_1(1 + l_1C_0\omega^2) - 2Gr_1l_1 \quad (= L_1)$$

Thus the effective self-inductance L_1 is greater in the case of capacitative coupling than in the case of inductive coupling, so that the capacity C_1 necessary to tune the network will be slightly smaller when capacitative coupling is used. Moreover, the effective resistance R_1 is also increased by capacitative coupling but to a greater extent than the effective self-inductance, so that the ratio of $\frac{R_1}{L_1}$ is increased. The tuning will, therefore, appear to be slightly less selective than when inductive coupling is used.

Apart from giving a different selectivity, the general shape of the resonance curve is not the same in the two cases. Let the reactances in the inductive and capacitative cases be X_i and X_c respectively, so that

$$X_i = l_1\omega - \frac{1}{C_1\omega} \quad \cdots \quad (24)$$

$$\text{and} \quad X_c = l_1\omega(1 + l_1C_0\omega^2) - \frac{1}{C_1\omega} \quad \cdots \quad (25)$$

The resonance curve (Fig. 12) will not be absolutely symmetrical about the ordinate AB corresponding to the maximum current. The extent of this asymmetry depends on the quantity which is varied in obtaining the resonance curve.

Suppose the frequency is varied, we have

$$\frac{dX_i}{d\omega} = l_1 + \frac{1}{C_1\omega^2} \quad \cdots \quad (26)$$

$$= l_1\left(1 + \frac{\omega_0^2}{\omega^2}\right) \quad \cdots \quad (27)$$

Where ω_0 corresponds to the resonant frequency. That is, in the case of inductive coupling, a small change in frequency produces a change in the reactance inversely proportional to the square of the frequency.

The resonance curve will, therefore, fall more rapidly on the low frequency side of the line AB than on the high frequency side. This (exaggerated) is shown in Fig. 12 by the dotted curve (i).

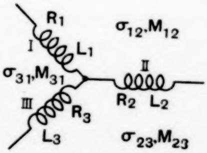


Fig. 13.—*Case of three mutual inductances.*

In the case of capacitative coupling, we have

$$\frac{dX_c}{d\omega} = l_1 + 3l_1^2C_0\omega^2 + \frac{1}{C_1\omega^2} \quad \cdots \quad (28)$$

$$= l_1\left(1 + \frac{\omega_0^2}{\omega^2} + 3C_0\omega^2\omega_0^2l_1\right) \cdots \quad (29)$$

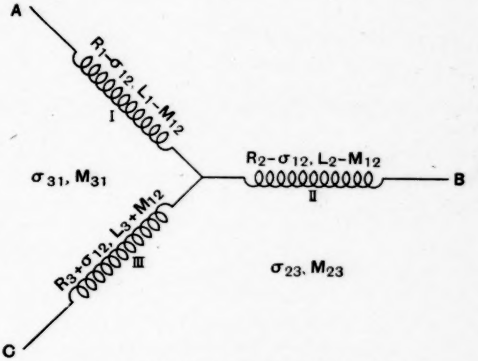


Fig. 14.—*First transformation of Fig. 10.*

In this case, therefore, the asymmetry is in the same direction but slightly less than in the case of inductive coupling. This is shown by the full line curve (c) in Fig. 12.

Perhaps a more usual method of tuning is to vary the capacity C_1, keeping the frequency constant. We can analyse this case in the same way. Thus

$$\frac{dX_i}{dC_1} = \frac{1}{C_1^2\omega} \quad \cdots \quad \cdots \quad (30)$$

$$\text{and} \quad \frac{dX_c}{dC_1} = \frac{1}{C_1^2\omega} \quad \cdots \quad \cdots \quad (31)$$

The asymmetry of the resonance curve is, therefore, the same for inductive and capacitative coupling. The curve will fall more rapidly on the low capacity than on the high capacity side of the maximum.

7. Limitations and Further Applications of Transformation.

It will be noticed that the transformation used cannot be employed in the case where the two mutual inductances have not a common point. This is a fairly common case but not as common as it may appear, for usually there is some common point, though it may be distant. It may be necessary to go as far back as the H.T. and L.T. batteries to find it.

The common point may not be the same for A.C. as for D.C. For instance, a large condenser joining two circuits may act effectively as a short circuit for the high frequency current, and the two points which are joined by the condenser may be taken as a common point in the two circuits.

However, the lack of a common point is not good, as it leaves the capacitative coupling vague and dependent on neighbouring objects. It is a condition that should be avoided if possible.

There is another fairly common case : that of several coils with mutual inductances to each other and having a single common point. This may occur, for instance, when one of the coils is tapped in the centre and this centre point acts as the common point.

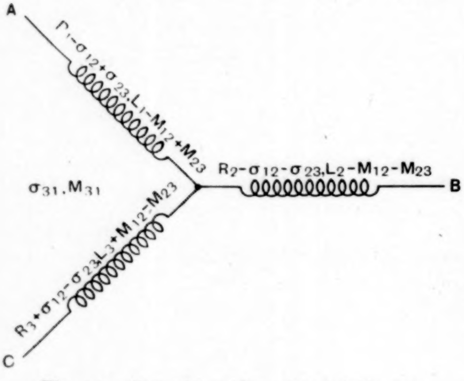


Fig. 15.—*Second transformation of Fig.* 10.

This case may be treated by a simple extension of the single transformation and can be solved by applying it a number of times. Let us take, for instance, three coils I, II, III, Fig. 13, having mutual inductances M_{12}, M_{23}, M_{31}, respectively with each other, as shown. Applying the simple transformation for mutual inductances to coils I and II, we obtain Fig. 14. Continuing to apply the same transformation between coils II and III we obtain Fig. 15, and finally, by another application of the same transformation, Fig. 16.

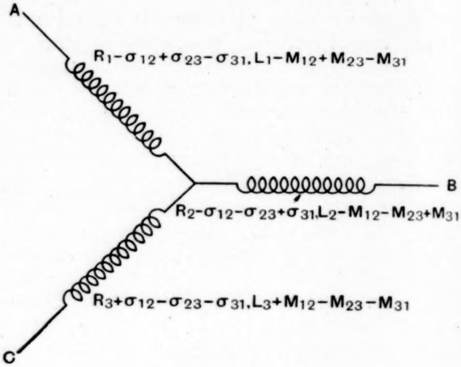

A
R1-σ12+σ23-σ31.L1-M12+M23-M31
B
R2-σ12-σ23+σ31.L2-M12-M23+M31
R3+σ12-σ23-σ31.L3+M12-M23-M31
C

Fig. 16.—*Third transformation of Fig.* 10.

If, moreover, there are capacitative couplings between the three coils, the transformation depicted in Fig. 6, using equations (18) to (23) can be applied. This transformation should be applied three times in succession (once for each of the capacitative couplings) *after* the transformation of the mutual inductance has been applied.

Some Measurements on Optimum Heterodyne.*

By J. F. Herd, A.M.I.E.E.

THE existence of an optimum value of local heterodyne voltage in the reception of continuous-wave signals is well known. Armstrong,† in 1917, described the effect in connection with grid rectification, while the matter has been fully treated theoretically by Prof. E. V. Appleton and Miss Mary Taylor‡ in their paper, "On Optimum Heterodyne Reception." The present paper gives fairly extensive experimental results, especially in the case of anode rectification, which are in good agreement with the theory given by Appleton and Taylor.

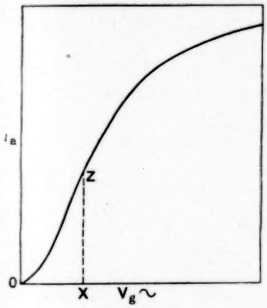


Fig. 1.

In the paper by these authors it is shown that if an alternating voltage be applied to a triode which is operating as an anode curvature rectifier, the relations between the anode-circuit mean (direct) current and the alternating input (grid) voltage are of the general form shown in Fig. 1. It is here seen that there is a region, centred on the point *Z*, where the curve is linear and of maximum slope. This is the point of optimum heterodyne, and, for the best results, the locally applied voltage should be made equal to *OX*. A small incoming signal will then produce a linear response in the rectifier anode circuit. For small signals there is also considerable gain in amplification, as compared with that which would result from a heterodyne voltage equal to the weak signal. Appleton and Taylor calculate, for example, that for a signal of 1 millivolt, applied to a given triode, the amplification with optimum heterodyne is 2,100 times that which would be given by an equal heterodyne.

The linearity of the audio-frequency response is also a factor that may be of great importance in many forms of measurement, as well as in various obvious practical applications where heterodyne reception is used as a method of frequency change.

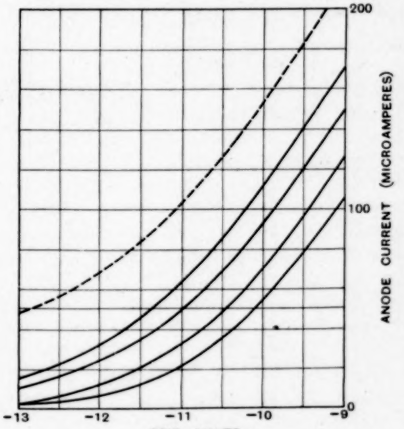


Fig. 2.

The measurements described in the present paper first became necessary in connection with the development of apparatus for the investigation of atmospherics, under the auspices of the Radio Research Board. It was desired to match several rectifying triodes in a number of similar recording receivers, and examination was first made to secure similarity of behaviour, as evidenced by curves of the type of that shown in Fig. 1. Some two dozen triodes (of thoriated-tungsten-filament type) were drawn at random from stock supplies, and their direct-current characteristics were taken round the bottom region of grid-volts/anode-current curvature. The tests were made in the actual circuit in which the triodes were required for operation. This was in the form of a 50,000-ohm feed resistance in the anode circuit, which was, in turn, capacitatively coupled to a low-decrement filter circuit tuned to the audio frequency of 1,000 cycles per second.

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* MS. received by Editor, October, 1929.

† *Proc. I.R.E.*, New York, 1917, Vol. 5, p. 145.

‡ *Proc. I.R.E.*, New York, 1924, Vol. 12, p. 277.

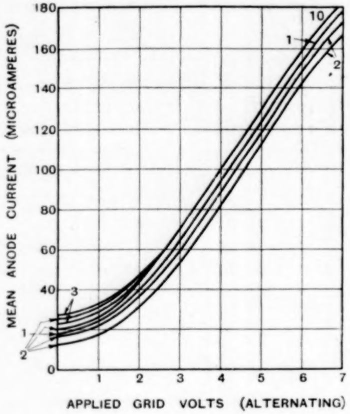

Fig. 3.

Considerable variation in details of d.c. characteristics was observed, but it was found possible to select fifteen triodes which manifested sufficient bend to be regarded as good rectifiers. Typical curves for this batch are given in the full-line curves of Fig. 2, the fifteen valves selected all falling within the limits shown in these curves.

The relations between applied alternating voltage and mean anode-circuit direct current were then obtained for each triode of the selected batch. Each triode was first adjusted for mean grid potential to the value of anode current considered (from the direct-current curves) to represent the most pronounced rectifying bend. A triode generator at 1,000 cycles—whose output voltage was measured throughout the observations by means of a laboratory standard Kelvin voltmeter—was joined to a suitable resistance, part of which was potentiometrically divided to the input circuit of the triode.

The results for the fifteen valves so tested are set out in Fig. 3.* The number affixed to the bottom of each curve shows the number of triodes adjusted, by control of the mean grid potential, to the same value of steady anode current in the absence of applied alternating voltage. It is worthy of note that ten out of the fifteen triodes, beginning at the different d.c. values shown, merge effectively into one common curve. The remaining five yield curves only differing by a few microamperes at the centre of their straight region, where the slope is practically identical with that of the other ten.

These curves suggest that the use of optimum heterodyne may help to equalise the performances of valves of the same type but differing in details of their d.c. characteristics, more especially round the bottom region of anode-current curvature. Definite tests of this effect were made with the results shown in Fig. 4.

Referring back to Fig. 2, the broken-line curve is the d.c. characteristic for a valve which showed inferior bend and was not included in the selected batch of fifteen dealt with in Fig. 3. This valve was compared with the best of the batch of fifteen.

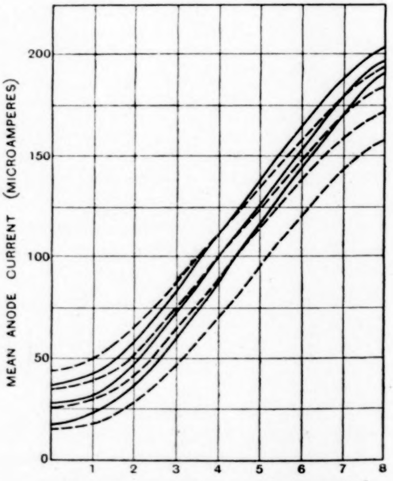

Fig. 4.

In Fig. 4 the three full-line curves are for the superior triode, when it was subjected to the same successive range of alternating input voltage, but beginning in each case at the different value of initial anode current shown for the curve. It is noteworthy that the slopes of the three curves, about their straight central regions, are sensibly identical, suggesting that, when the optimum value of heterodyne voltage is applied, the d.c. adjustment to rectifying bend is not very critical. Similar curves for the inferior rectifier are shown in the broken-line curves of Fig. 4, where the three upper curves, at least, manifest the same comparative latitude of d.c. adjustment. It is also notable that the three upper curves of this group yield slopes much more closely comparable with those of the full-line curves than would have appeared likely from consideration of the d.c. characteristics of Fig. 2.

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* In Figs. 3 and 5 the numerals affixed to the various curves show the number of triodes which fall on each curve.

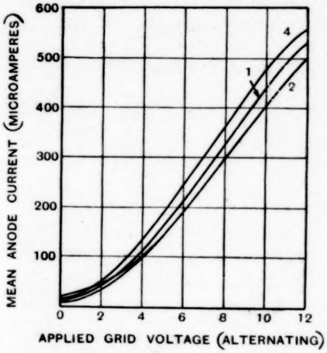

Fig. 5.

Some of the thoriated-tungsten-filament valves, dealt with above, were used in the complete apparatus, but later change was made to valves with filaments of the oxide-coated pattern. Before the change, however, the new valves were examined for their behaviour as rectifiers with optimum heterodyne, a dozen batch being tested in the manner already described. The d.c. characteristics, taken in the working circuit, all fell within limits generally similar in shape to those of Fig. 2. Typical results of the application of the alternating input voltage are shown, for seven of the triodes, in Fig. 5. It is noticeable that these curves are again more closely similar than the d.c. characteristics might, at first glance, have suggested. The remainder of the batch gave substantially similar results.

The complete apparatus in which these rectifiers were to be used was required to maintain a uniform quantitative performance, and routine check of the operating conditions was considered essential. This is effected by the wiring of a jack into the anode circuit of the rectifier, to permit the ready introduction of a suitable d.c. meter. With the heterodyne voltage cut off, the mean grid potential of the detector valve is adjusted for the rectifying bend, as determined by the corresponding anode current, read from the d.c. curves and already noted for each valve to be used as a rectifier. The heterodyne voltage is then introduced and its value adjusted to obtain the mean anode-circuit current corresponding to the value of optimum heterodyne voltage.

This has been found convenient in operation while the preliminary testing of the valves is amply justified in apparatus intended for systematic quantitative working.

The measurements described above were made some time ago, and the apparatus employing the facilities mentioned was in routine operation for a considerable period. Subsequent experimental work in the redesign and reconstruction of the apparatus —necessitated by other causes—provided opportunity of further measurements on the subject. These measurements were made particularly with the view of experimental verification of :—

(1) The existence of optimum heterodyne —in the form of a maximum value of audio-frequency output as the applied heterodyne voltage is varied, with a constant signal.

(2) The linearity of audio-frequency output with small values of received signal.

(3) The gain in amplification of weak signals due to optimum heterodyne, as compared with the use of a heterodyne voltage equal to that of the weak signal.

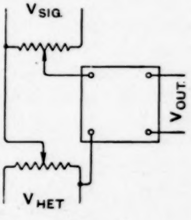

Fig. 6.

The general method of experiment is shown in Fig. 6. Two potentiometers, each of 10,000 ohms, were used in conjunction with suitable screened oscillators to supply voltages representing respectively the local heterodyne and the incoming signal. The potentiometers were tapped boxes, with the resistances wound anti-inductively and anticapacitatively (Ayrton-Perry winding) on flat cards. The heterodyne voltage could be varied up to 8 or 10 volts and the signal voltage from 0.002 to about 2 volts. The input to each potentiometer was measured by means of a thermojunction instrument, and tests were made with different fixed values of signal voltage while the heterodyne voltage was varied over its range.

Measurements were made with the detector feeding into three different types of circuit :—

(*a*) A two-stage audio-frequency tuned amplifier, the anodes fed through iron-cored chokes and capacitatively coupled to tuned grid circuits. The tuning of the stages was slightly spaced to give a rounded top at 1,000 cycles per second and pass a band-width of 20 cycles, with an overall amplification of about 100 at the peak frequency (*i.e.*, when used with grid bias proper to an amplifier and with a direct audio-frequency input).

(*b*) A tuned audio-frequency amplifier of frequency characteristics similar to (*a*) but with the anodes resistance-capacity coupled, and giving a total amplification of about 20.

(*c*) An iron-cored intervalve transformer of commercial (broadcast) pattern and with a sensibly flat frequency characteristic over the audio range.

The greater number of measurements were made with the condition (*a*), as this represented the normal conditions of the apparatus. Sufficient measurements were, however, made with (*b*) and (*c*) to show that the effects were generally similar.

For tests (*a*) and (*b*) the heterodyne voltage was at about 12 kc. per second with the signal at 13 kc. per second, chiefly, again, because the apparatus was already set for these values. The 1,000-cycle tuned circuit curve had sharply cut-off tails, which completely prevented any radio-frequency voltage from appearing at the output end, so that only the 1,000-cycle audio-frequency voltage, emanating from the beats, was detectable. For tests (*c*) the radio frequencies of 12 or 13 kc. per second came strongly through the iron-cored transformer, and were detectable at the output with the 1,000-cycle beat note superposed. The radio frequencies were therefore increased to about 50 kc. per second, with a frequency difference to give a 1,000-cycle beat note.

In each case the output voltage at 1,000 cycles per second was measured by means of a valve voltmeter, the apparatus already set up containing a portion (including a galvanometer) capable of being calibrated and used for this purpose. The galvanometer was a multi-range instrument, so that a relatively wide range of voltages could be measured, and outputs as low as .05 v. and as high as 7 v. could be read with accuracy. This apparatus was calibrated for use as a voltmeter at 1,000 cycles per second by means of an audio-frequency oscillator and one of the potentiometers later used for the radio-frequency injections.

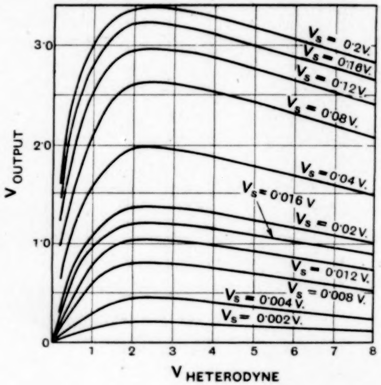

Fig. 7(a.)

The curve of mean anode-circuit direct current against alternating input (grid) voltage was first determined for each case, giving results of the general form of Fig. 1, which may conveniently be referred to as the "rectification curve" of the valve. From this the position of optimum heterodyne could be determined, while the frequency used for the purpose was that later used to produce the heterodyne beats.

A complete series of values of the output audio-frequency voltage at 1,000 cycles per second was then made for various values of heterodyne and of signal voltages.

Results for the condition (*a*) above are given in Figs. 7 (a) and (b), showing the variation of output audio-frequency voltage V_0 against applied heterodyne voltage V_H, each curve being for the fixed value of signal voltage V_s shown. These signals ranged from 2 millivolts to 0.2 volts for Fig. 7 (a), while Fig. 7 (b) continues, on a closer scale of ordinates, up to signals of 2 volts.

The curves reveal a distinct optimum, especially for smaller signals. Too low a value of heterodyne voltage is obviously inefficient, as the curves rise steeply from origin. On the upper side of the optimum region, it is seen that a randomly chosen but excessive heterodyne voltage may drop the possible output by as much as 50 per cent., *e.g.*, the curve for 0.002 v. signal. Even the strong signals of Fig. 7 (b) reveal an optimum region, although, naturally, such signals would in practice call for less critical conditions than the relatively weak signals of the lower part of Fig. 7 (a).

Results for the condition (*b*) are shown in Fig. 8, where the curves are of a form generally similar to those of Fig. 7. In connection with the use of an excessive heterodyne voltage it is interesting to note that for a signal of 0.008 v. the ratio of optimum output to that with 8 volts heterodyne is 1.44 for Fig. 8 and 1.54 for Fig. 7 (a). With a 0.2 volt signal the corresponding ratios for each curve are almost equal at 1.18.

Lastly in this connection, curves are shown in Fig. 9 for two different values of signal voltage (at about 50 kc. per second) with the transformer coupling of condition (*c*). The optimum in this case is surprisingly pronounced. As the considerable difference in the shape of these curves (from those of Figs. 7 and 8) suggested some effect connected with the transformer, two other transformers, of similar general type but of different voltage ratios, were later tried. One of these gave results substantially similar in shape to those of the heavy lines of Fig. 9. The other gave results shown by the dotted curves of that figure. It was noticeable that in all cases of transformer coupling the rectification curve showed a tendency to bend at earlier inputs than with the choke or resistive coupling. In the case of the heavy-line curves of Fig. 9, the optimum at a heterodyne of 2.5 v. is in good agreement with the rectification curve, but the falling-off beyond 3 v. of input voltage is more rapid than that curve would have suggested. Even the dotted curve of Fig. 9 shows earlier falling-off than the decreasing slope of the corresponding rectification curve for this case would have led one to expect.

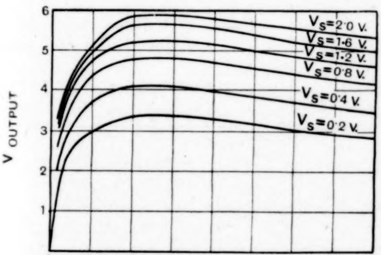

Fig. 7(b).

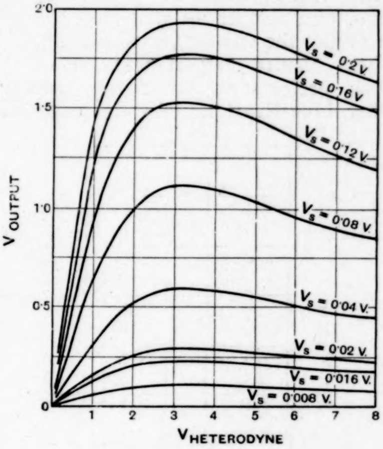

Fig. 8.

It should be mentioned, in passing, that the rectification curves in all the cases (*a*), (*b*) and (*c*) mentioned here were for quite different valves from those of the family of rectification curves shown in Fig. 3, and that no comparisons can therefore be drawn from them. The position of the optimum output in Figs. 7 and 8 is in good agreement with the rectification curves determined for these cases. In the case of Fig. 9 the optimum is, as already stated, in good agreement, but the falling-off beyond 3 or 4 volts input is unexpectedly large.

Another peculiar effect of the transformers was observed in determining the rectification curves. The oscillator used to give the oscillating input was capable of a variation of frequency from 120 kc.s to 48 kc.s, its output being practically constant over this range. Keeping the oscillator output at a steady value, it was observed that, as its frequency was swept over the range stated, a very sharp dip of rectifier anode current occurred at about 95 kc.s. No corresponding dip was observed in the oscillator output, which was separately checked. This effect was observed with two of the transformers in practically equal degree, and not at all with the third (*i.e.*, that giving the dotted curves of Fig. 9).

These results suggest features of transformer performance that are worthy of further investigation. As the experiments were intended, however, primarily to cover the case of optimum heterodyne as applied to the choke-coupled tuned audio-frequency apparatus, no further investigation of the matter was made.

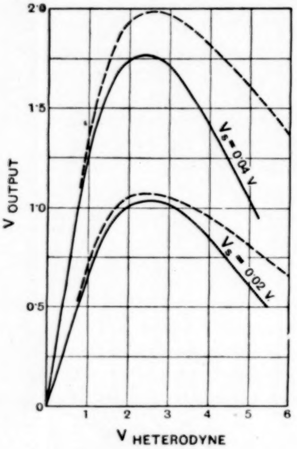

Fig. 9.

Typical curves showing the relations between input signal and output audio-frequency voltage are given for each of the above conditions in Figs. 10, 11 and 12. In each case it is seen that for a region of small input signals the output increases linearly, a fact which is of considerable importance in many practical applications of the heterodyne principle, notably, perhaps, in supersonic reception and other forms of frequency changing, and in the applications of such apparatus to measurements. The relatively early bending in the case of the choke-coupled system is no doubt due to overloading in the stage subsequent to the detector. It may, however, be mentioned here that the complete working apparatus—of which that used forms a part—consists of a radio-frequency stage, followed by the detector and tuned audio-frequency system used in these measurements, and, in turn, by a flat audio-frequency (transformer coupled) amplifier whose output is measured on a recording instrument in the normal operation of the apparatus. Calibration of the complete apparatus reveals a satisfactory linearity of input/output relations over a range of input voltages of nearly 20 times that to which the apparatus is normally subjected in practice. The linearity of the input/output relations of Fig. 10 is thus evidently much more than adequate for the purpose for which the apparatus was designed.

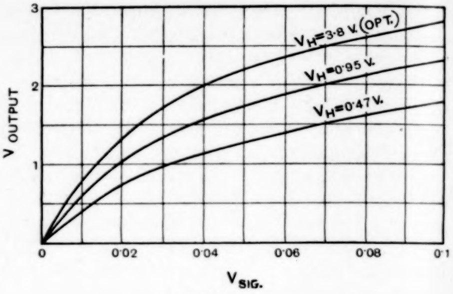

Fig. 10.

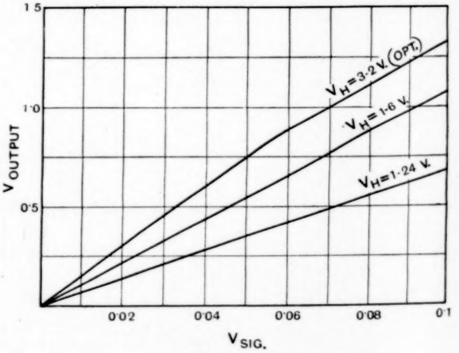

Fig. 11.

The gain in amplification of weak signals due to the use of optimum heterodyne, as compared with the use of a heterodyne voltage equal to the weak signal have been extracted from the series of measurements of condition (*a*). The results are shown in Fig. 13 where the ratio of output voltage with optimum heterodyne (V_0 Opt.) to that with equal heterodyne (V_0 Eq.) is plotted for signals from 2 millivolts to 2 volts. In Appleton and Taylor's paper it is shown that the ratio V_0 Opt/V_0 Eq. is a function of the form $K\frac{1}{V_{sig.}}$, where K is a factor depending on the valve constants. Fig. 13 confirms this relationship for signals up to about 0.2 v., when the curve of the ratio begins to bend towards the value of 1 as the signal approaches in strength to the optimum heterodyne voltage. The improvement in amplification of a weak signal (*e.g.*, of 2 millivolts applied to the detector grid) is between 700 and 800, which is in good agreement with the calculated values of Appleton and Taylor, allowing for the difference of valve characteristics.

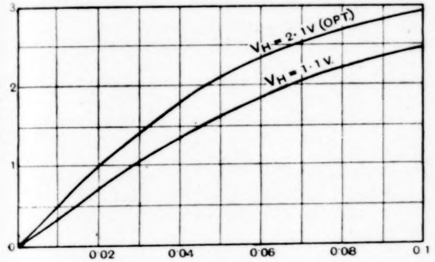

Fig. 12.

There seems little doubt that it is the great amplification obtainable in this manner which accounts for the sensitivity of the homodyne or zero-beat method of receiving weak modulated signals. In the case of radio telephony of the typical 50 per cent. modulation, weak signals will give feeble sidebands beating with a carrier also very feeble compared with the value of steady oscillation necessary to achieve the optimum conditions. A local heterodyne of exactly the frequency of the carrier will then have the effect on the sidebands shown above for a weak incoming signal of single frequency.

Conclusions.

When a triode valve is operating as an anode-curvature detector with local heterodyne there is a value of the heterodyne voltage for which the audio-frequency output, due to the formation of beats, is a maximum. With this optimum value of heterodyne voltage the audio-frequency output varies linearly with small input signal voltages, while the output from small signals may readily be several hundred times that which would accrue with a heterodyne voltage equal to the small signal.

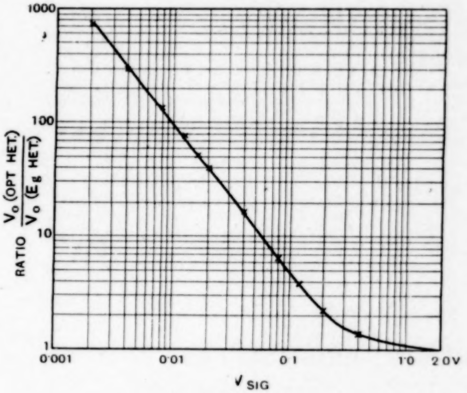

Fig. 13.

The use of such an optimum heterodyne may tend to equalise the performance, as rectifiers, of valves which appear fairly widely different in details of their rectifying characteristics, while, even with a single valve, the use of optimum heterodyne affords a comparative latitude of adjustment of mean grid potential to the point of rectifying curvature.

The advantages quoted above are of practical importance in most applications of the heterodyne principle, *e.g.*, the reception of signals, especially of weak signals, frequency-changing methods generally, including supersonic-heterodyne reception, audio-frequency sources employing the beat principle, etc., and in the homodyne or zero-beat method of reception of modulated signals.

The work described has been carried out in connection with the programme of the Radio Research Board of the Department of Scientific and Industrial Research, to whom the author is indebted for permission to publish the results.

Abstracts and References.

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PROPAGATION OF WAVES.

Observations relatives à la Radioélectricité et à la Physique du Globe : Faites à l'Occasion de l'Éclipse totale de Soleil du 9 Mai 1929 à Poulo Condore—Indo-Chine (Observations relating to Radio Electricity and the Physics of the Earth : Made on the Occasion of the Total Eclipse of the Sun, 9th May, 1929, at Poulo Condore —Indo-China).—J. B. Galle. (*L'Onde Élec.*, June, 1930, Vol. 9, pp. 257–265 and loose chart.)

First instalment of a full description of these tests, a *Comptes Rendus* Note on which was abstracted at some length in March Abstracts, p. 151.

In this Note it was mentioned that the echo-times ranged from 5 to 25 secs. In the present paper the writer states that for the greater part of the time the " strong " echoes (1/3rd to 1/10th of primary signal strength ; regular, reproducing the signal quite faithfully) had times equal to or greater than 20 secs. A few, however, had times shorter than 10 secs., but only very few had times between 10 and 20 secs. An incident (the accidental omission of one signal) gave reason to believe that these short-delay echoes (5–10 secs.) were really echoes of the *preceding* signal and therefore had times of 35 and 40 secs. ; but there was no opportunity to confirm this.

Eigenschaften von ultrakurzen Wellen (Properties of Ultra-Short Waves).—K. Stoye. (*Zeitschr. f. hochf. Tech.*, June, 1930, Vol. 35, pp. 235–236.)

Range tests over hilly country in the Hartz district, with 3.40, 5.00 and 6.80 m. waves. At 1.1 km. from the transmitter there was a hill sloping rather sharply both at the near and at the far side ; its summit was about 63 m. above the transmitter level. The 3.4 m. wave was inaudible on descending only 8 m. on the far side, whereas the 5 m. wave persisted to half way down and the 6.8 m. wave was audible on the level ground at the foot of the hill : in fact this last wave gave good signals over several kilometres of hills and valleys. In receiving the 5 m. wave on the down slope of the hill, to get strong signals it was necessary to hold up the receiver (which had no aerial) higher and higher as the crest was left behind.

Tests from cellar to cellar in the town gave negative results with the 3.4 m. wave, which also failed over hillocky ground ; though the apparatus gave a range of 7 km. on this wave when the transmitter was raised 12 m. above the ground. The 5 m. wave, on the other hand, could be received well in deep-lying cellars and troughs of valleys.

The transmitter employed had an anode power of 12 w., with a push-pull connection ; the wave was modulated by audio-frequency a.c. " As transmitting aerial the arrangement suggested by Fuchs of Vienna was employed which uses no earth or balancing capacity, since this has shown itself very successful in all work with ultra-short waves." The receiver was of the super-regenerative type due to Busse of Jena (*cf.* Hollmann, Feb. Abstracts, p. 98 ; Chiba, June, p. 334 ; Pistor, July, p. 395 ; Uda, July, p. 392) ; other types, *e.g.*, push-pull and Hartley circuits, were tried, but the first type surpassed them all in sensitivity.

Some Notes on Wireless Methods of Investigating the Electrical Structure of the Upper Atmosphere (II).—E. V. Appleton. (*Proc. Physical Soc.*, 15th June, 1930, Vol. 42, Part 4, pp. 321–339.)

The present paper continues in three directions the discussion begun in Part I (1929 Abstracts, p. 145) :—in Section 2 it brings up to date the general enquiry into the significance to be attached to the term " effective height " of the ionised layer, by the inclusion of a discussion of a new wireless method of height determination recently described by Mirick and Hentschel (1929 Abstracts, pp. 500–501) ; in Sections 3 and 4 it presents a discussion of the relations existing between the equivalent and optical paths of the space waves and the theoretical significance of the variations of these quantities with time and with the frequency of the transmitter ; and in Section 5 it ends with a discussion of experimental data which consists in part of an enquiry as to how far the theoretical conclusions of this and the previous paper fit in with the experimental results, and in part of deductions which can be made from the data as to the actual electrical structure of the upper atmosphere.

In Section 2, the summarised conclusions from this and the preceding paper are that the frequency-change and the group-retardation methods both measure the quantity $c\int\frac{ds}{U}$ for the space waves, where ds is an element of the space wave track along which the group velocity is U ; the angle-of-incidence and the Mirick and Hentschel moving-transmitter methods both enable us to find the angle of incidence of the space wave at the lower boundary of the layer ; and for cases where the influence of the earth's magnetic field is negligible (*e.g.*, for short waves) all four methods enable us to deduce the equivalent path $\int\frac{ds}{\mu}$ of the space waves (μ being the refractive index at any point along the path), from which the equivalent height may be calculated.

In connection with the frequency-change method (formerly called the wave-change method) the writer mentions that a future paper will deal with experiments already carried out with a modification of this method specially suitable for ultra-short wave working, in which the *modulation* frequency of a telephony station, and not the carrier frequency, is varied continuously through a small range.

In Section 3 the writer discusses two possible types of ionisation gradient, where N varies directly as the height y above h (the height of the lower boundary) and where it varies as the square of y. In either case, since the actual height reached by any particular frequency f may be found and since at that height $N = \pi m f^2/e^2$, it is possible to deduce the relation between ionisation and height. He mentions the analogy between the problem and the dynamical problem solved by Abel many years ago: the equation to be solved is, in fact, that known as Abel's integral equation. In the case of vertical incidence, the result arrived at is

$$y_0 = \frac{1}{\pi}\int_0^{f_0} \frac{\phi(f)}{(f_0^2 - f^2)^{\frac{1}{2}}} \cdot df;$$

from this, if the heights to which different frequencies penetrate are known, the ionisation as a function of the height may be deduced.

Section 4, dealing with the temporal rates of change of optical and equivalent paths, describes a method of measuring the rate at which the optical path is changing with time, even though the magnitude of the optical path itself is not known. This variation of the optical path may be due either to an alteration of the height of the layer as a whole, or to an alteration arising from some readjustment of the ionisation; and the writer shows how these two different causes would produce different relations between the rates of change of the equivalent and of the optical paths.

In Section 5 the writer applies this result to the interpretation of experimental data recently obtained as to changes in the optical path. Other experimental work dealt with here relates to measurements of equivalent height by different methods and a comparison of the results: the demonstration of the existence of more than one ionised region in the upper atmosphere: and the variation of equivalent path with frequency (Sec. 3).

WYNIKI PIERWSZYCH BADAN NAD ROZCHODZENIEM SIE FAL KROTKICH NA OBSZARZE POLSKI

(The Results of the First Investigations on the Propagation of Short Waves in Poland).—D. M. Sokolcow. (*Wiadomości i Prace Inst. Radjotech.*, Warsaw, No. 2/3, Vol. 2, pp. 43–80.)

After a survey of past investigations of waves below 100 m. and a detailed description of the stations and apparatus used in the present tests in Poland, the writer describes these tests and their results. They were limited to 30, 40, 50 and 60 m. waves, the time of year being Oct.–Dec., 1929. These waves were found to be day waves exclusively, unsuitable for night use. The time over which reception was possible decreased, and the strength of signals increased, with decrease of wavelength. Once reception was assured, increase of power at the transmitter did not increase the strength of the signals. The effects of sunrise and sunset were very marked: immediately after sunrise the signals increased suddenly and by a large amount, falling then to the normal strength: at sunset they increased largely and suddenly and then fell suddenly, practically to zero. Both increase and decrease showed violent fluctuations. Fading was strong (from 1.2 mA. to 0.2 mA. or zero) and frequent (3–5 secs. every 15 secs.).

RECOMBINATION OF ELECTRONS AND POSITIVE IONS IN THE UPPER ATMOSPHERE.

—T. L. Eckersley. (*Nature*, 3rd May, 1930, Vol. 125, pp. 669–670.)

A letter giving a short description of a method of obtaining the recombination coefficient of the electrons and ions in the upper atmosphere, arrived at by the use of some recent radio telegraphic observations. "The method depends essentially on the measurement by radio methods of the maximum density of electrons in the layer at various times of the night after the ionising agent, the sun's ultra-violet light, has been removed."

Let N be the electron density; the number of electrons required to bend back to the earth a ray of frequency ν sent out by a radio transmitter at an angle of elevation θ is given by the relation

$$\cos\theta = \frac{R + h}{R}\sqrt{1 - \frac{Ne^2c^2}{\pi m \nu^2}}.$$

When h, the height of the layer, is small compared with the earth's radius, this may approximately be taken as

$$\frac{Ne^2c^2}{\pi m} = \sin^2\theta + 2x,$$

where $x = \frac{h}{R}$.

"In general, if such a frequency ν is chosen that $\frac{N_{\text{max.}}\, e^2c^2}{\pi m \nu^2} = \delta < 1$, then those rays for which $\sin^2\theta > \delta - 2x$ will not be returned to earth."

The method thus consists in determining the value of $\theta_{\text{max.}}$, the greatest angle at which rays are reflected to earth. The working of the facsimile device between New York and England on a wavelength of 22 m. provided an opportunity of accurate measurement of these ray angles.

"If a single short impulse $< \frac{1}{1000}$ sec. duration is sent out by the transmitter, it is generally reproduced as 2, 3, 4 or even 5 separate images corresponding to various rays of elevation at the receiving end θ_1, θ_2, θ_3, θ_4, θ_5, etc. From the speed of the receiving drum it is easy to calculate the time intervals T_{1n} between these signals and using the relation

$$T_{1n} = \frac{d}{c}\left(\frac{1}{\cos\theta_n} - \frac{1}{\cos\theta_1}\right) = \frac{d}{c}\left(\frac{1}{\cos\theta_n} - 1\right),$$

where d is the distance of transmitter from receiver (assuming $\cos\theta_1 = 1$), to calculate accurately the value of θ_n."

Values of θ up to 35° were obtained and the value of $\theta_{\text{max.}}$ was found to decrease throughout the night. A curve representing $N_{\text{max.}}$ as a function of the time after sunset was thus secured and is reproduced in the letter. The theoretical recombination curve is $N = \frac{N_0}{1 + N_0 \alpha t}$, where t is the time after sunset. The value of α, the recombination coefficient, can thus be determined from the best fitting curve and its value appears to be close to 8.75×10^{-11} cm.^{2}/sec.

Assuming the electrons in temperature equilibrium at 300° abs., v, the electron velocity, is 1.1×10^7 cm./sec. and σ, the recombination radius, is found to be 1.4×10^{-9} cm. "If the actual value of v were v_0 and not 1.1×10^7, the value of α would be

$$1.4 \times 10^{-9} \sqrt{\frac{1.1 \times 10^7}{v_0}} \text{ cm.}, \sigma = 1.4 \times 10^{-9}/\sqrt{28V},$$

where V is the voltage equivalent of the electrons of velocity v. This seems a reasonable value in view of the theoretical work of Kramers, Eddington, Milne and others."

"Only recombination radii for stripped nuclei can be obtained theoretically from Kramers' formulæ. . . . No reasonable adjustment of V [the equivalent voltage of the recombining electron] can make this formula agree for the ionised hydrogen atom, and the least value of Z [the atomic number] required is 7, r [the number of the quantum state in which the electron is captured] $= 1$, in which case σ is 1.22×10^{-9}.

"The pressure at the measured 'equivalent height' at which the observed recombination occurs, namely, 340 km., is entirely unknown, but certain results, independent of this pressure, may be given.

"The mean free life of an electron between ionisation and capture is approximately 5 hours. Assuming $v = 1.1 \times 10^7$, then the total distance travelled in this time is 2×10^6 km., although its final distance from the origin is much less, of course, depending on the number of collisions made with other molecules.

"During this period it makes about 120 collisions with ionised atoms within a radius of 2.74×10^8 cm. (the assumed average radius of the atoms of the atmosphere). These last figures depend on the assumed value of v."

Comparaison entre la Quantité de Taches solaires, l'Activité magnétique terrestre et la Puissance des Signaux radioélectriques émis sur grande Ondes (Comparison between Sunspot Numbers, the Earth's Magnetic Activity, and the Strength of Long Wave Wireless Signals).—L. W. Austin. (*L'Onde Élec.*, June, 1930, Vol. 9, pp. 291–292.)

French version of the paper dealt with in July Abstracts, p. 389.

Ozone and the Conductivity of the Atmosphere.—E. Regener. (*Gerlands Beitr.*, No. 1, Vol. 24, 1929, pp. 70–71; summary in *Science Abstracts*, Sec. A, April, 1930, p. 410.)

Dielectric Constants of Helium and Argon.—G. W. Brindley. (*Proc. Leeds Phil. and Lit. Soc.*, Dec., 1929, pp. 1–7; summary in *Science Abstracts*, Sec. A, May, 1930, pp. 516–517.)

The Fading and Distortion of Distant Signals.—A. Dinsdale. (*Wireless World*, 14th May, 1930, Vol. 26, pp. 479–483.)

Observations on the duplication of television images received in Berlin from the 261-metre National programme transmitter at Brookmans Park. The appearance of "ghost" images above those in full synchronisation is attributed to the arrival of space waves out of phase with the ground waves. The total time lag between the two images is calculated at 3.8 millisecond, and it is suggested that from this it is possible to work out the length of the path followed by the space wave and by triangulation to calculate the height of the Heaviside layer.

Om Fältstyrkemätningar och deras Betydelse (Field Strength Measurements and their Significance).—S. Lemoine. (*Teknisk Tidskr.*, 5th July, 1930, Vol. 60, pp. 409–412.)

Includes field strength charts of Motala, Gothenburg, Hörby and Sundvall broadcasting stations.

Action mécanique exercée sur un Conducteur par les Ondes électromagnétiques (Mechanical Action exerted on a Conductor by Electromagnetic Waves).—S. Husson. (*Comptes Rendus*, 7th July, 1930, Vol. 191, pp. 33–35.)

Hertz observed the mechanical action of stationary waves; the present writer has demonstrated another type of mechanical action, much smaller in magnitude, which is only observed on the passage of waves in progress, and which is in the direction of propagation of the waves. For 17.5 cm. waves and an electric field of 0.03 v./cm., the force is of the order of 10^{-7} dyne. The experiment is described and the mathematical theory given.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

Le Repérage radio-électrique des Tempêtes de Sable du Sahara à grande Distance (The Long-distance Tracking, by Wireless D.F., of Sand Storms in the Sahara).—J. Lugeon. (*Comptes Rendus*, 7th July, 1930, Vol. 191, pp. 61–64.)

These sand storms give rise to a type of atmospheric unknown in Central Europe—heard as an intermittent machine-gun crackling which stops abruptly, and giving on the screen of a cathode-ray oscillograph a large spot of remarkable regularity, while ordinary clicks and grinders show as zig-zags or oscillations. These disturbances appear to carry between 500 and 1,000 km.; they evidently do not cross the Mediterranean, because though recorded perfectly by the writer's "atmoradiograph" at El Goléa and observed at three Sahara stations they gave no trace on a similar recorder at Zurich or on a Bureau recorder at Saint Cyr. The writer concludes that three watching posts, at named points, would triangulate all Central Sahara sand storms and would be of great use as a protection to aerial services.

An "atmoradiograph" record on a day free from these storms shows a very sharp bend upwards in the atmospherics-per-minute curve, the frequency being quadrupled or more in a few minutes; this occurs 53 minutes after sunset. The time corresponds to the moment when the tangential rays of the sun are at a height of 121.6 km. in the zenith above El Goléa. This is probably the height of the Heaviside layer. Thus while in Europe the writer could use only the sunrise effects for his method of "sounding the atmosphere" (see 1929 Abstracts pp. 444, 502, 626), in the Sahara the sunset effects lend themselves equally well to this process.

Measuring the Natural Time of a Klydonograph by Surges of Known Length.—Stoerk and Bungardean. (*See* under "Subsidiary Apparatus.")

Über die Schwankungen der Ionisation der Bodengase in Sibirien im Laufe des Jahres (On the Fluctuations of the Ionisation of Gaseous Emanations from the Earth in Siberia in the Course of the Year).—M. Orlowa, G. Hodalewitsch and N. Ljamin. (*Physik. Zeitschr.*, 15th June, 1930, Vol. 31, No. 12, pp. 585–589.)

Neue Untersuchungen über die Ionisierungsbilanz der Atmosphäre auf Helgoland (New Investigations into the Ionisation Balance of the Atmosphere over Heligoland).—V. F. Hess. (*Wiener Ber.*, No. 3/4, Vol. 138 [IIa], pp. 169–221; long summary in *Physik. Ber.*, 15th May, 1930, Vol. 11, pp. 1092–1093.)

Cf. also 1929 Abstracts, pp. 147 and 202.

Sur le Courant Électrique vertical atmosphérique (The Vertical Electric Current of the Atmosphere).—Ch. Maurain, G. Homery and G. Gibault. (*Comptes Rendus*, 16th July, 1930, Vol. 191, pp. 87–89.)

As a result of six years' observations at Val Joyeux, it is found that the mean values for the currents, including both the more general downward currents and the upward ones which at Val Joyeux occupy 11 per cent. of the time, is 3.28×10^{-7} e.s.u. *Taking the downward currents only*, the value is 4.40×10^{-7}; this difference, though small, is regular and consistent, and if it applied all over the earth would amount to a value which is of the same order as that calculated for lightning strokes.

The vertical current is at its maximum in summer. Of the factors on which it depends, the electric field is greatest in winter and the conductivity in summer; it is therefore the variation of the conductivity which controls the current maximum. Generally, in fact, it is the conductivity which controls the current (except when the electric field attains exceptional values in the presence of storm clouds); *e.g.*, current and conductivity are both generally larger in fine weather than in overcast conditions.

Effect of Condensation-Nuclei in Atmospheric-Electric Observations. — G. Builder. (*Terr. Mag.*, Dec., 1929, Vol. 34, pp. 281–286; Summary in *Science Abstracts*, Sec. A, May, 1930, p. 517.)

Variation of the Electric Potential Gradient in the Lower Atmosphere.—J. G. Brown. (*Phys. Review*, No. 1, Vol. 35, 1930, p. 135.)

Influence de la Constitution géologique du Sol sur les Points de Chute de la Grêle (Influence of the Geological Constitution of the Ground on the Points where Hail frequently falls.)—C. Dauzère and J. Bouget. (*Comptes Rendus*, 30th June, 1930, Vol. 190, pp. 1574–1576.)

Further development of the work dealt with in Abstracts, 1928, p. 517; also see 1929, pp. 41 and 568.

PROPERTIES OF CIRCUITS.

Über Frequenzverdopplung mit Elektronenröhren (Frequency Doubling by Thermionic Valves).—W. Bunimowitsch. (*Zeitschr. f. hochf. Tech.*, June, 1930, Vol. 35, pp. 223–231.)

A paper from the Leningrad State Phys. Tech. Institute. Author's summary :—A method of calculating a valve frequency doubler is given. Formulæ are derived expressing the dependence of the values of d.c. and a.c. output, and the corresponding grid voltages, on the angle $a = \omega_1 t$. These relations are used, by a graphical method, to determine the d.c. and a.c. outputs as functions of the grid voltages. For all the relationships derived, approximate algebraic expressions are given which are suitable as a basis for practical calculation.

Practical frequency doubling circuits are described and certain points in connection with these, *e.g.*, retroaction on the preceding stage, self-excitation, and regeneration at the doubled frequency, are considered. Finally the calculated results are confirmed by experiment.

Oscillations sinusoidales et de Relaxation (Sinusoidal and Relaxation Oscillations).—B. van der Pol. (*L'Onde Élec.*, June, 1930, Vol. 9, pp. 245–256.)

Author's summary :—"The author considers an electrical circuit comprising a self-inductance and a capacity, both constant, and a resistance which is a function of the potential v; and corresponding, therefore, to the equation

$$L.\frac{d^2v}{dt^2} + R(v)\frac{dv}{dt} + \frac{v}{C} = \frac{E(t)}{C}.$$

If the resistance $R(v)$ is negative when the absolute value of v is below a certain value, and positive for larger values [of v], it may be thought that in the absence of imposed e.m.f. $e(t)$ the system will be capable of pure oscillations of definite period and amplitude; the energy received during that part of the period when R is negative compensating exactly for the energy dissipated when R is positive.

"The author selects, for the normal form of oscillations of this type, those defined by the equation $y'' - \epsilon(1 - y^2)y' + y = 0$. He shows that in the case where ϵ is very small the periodic solution, reached at the end of a very large number of oscillations, is very close to a sinusoidal form. In the case where ϵ is very large the periodic solution, reached very rapidly, has a form very different from sinusoidal. These extreme cases are already attained for $\epsilon = 0.1$ and $\epsilon = 10$ respectively. For $\epsilon = 1$ (for example) the form is intermediate.

"The extreme case where ϵ is very large possesses a special interest because it includes a large number of natural periodic phenomena whose assimilation to a sinusoidal oscillation is manifestly impossible. Such oscillations present, in addition to their particular form, three remarkable physical characteristics: first their *period* is given by a product of two quantities of the type CR or $L \times \frac{1}{R}$ (relaxation time), instead of being given—like the period of a sinusoidal system—by the square root of the product of two quantities of the type LC. Secondly, they fall readily into synchrony with a sinusoidal force of frequency quite different from their own: but though their *period* can thus be varied easily within wide limits, their *amplitude* remains practically constant.

"Thirdly, under the influence of a periodic force of frequency greatly superior to their own, they adopt a frequency which is an exact submultiple of the frequency of the controlling sinusoidal oscillation, thus giving a frequency demultiplication. The author considers in detail a large number of examples of relaxation oscillations, taken from mechanics, acoustics, electricity, biology, political economy, etc."

The present paper is only the first instalment. For other references to these oscillations, see Abstracts, 1928, pp. 34, 579 and 686; 1929, pp. 42, 268; 1930, pp. 40, 209.

The Numerical Expression of Selectivity.—R. T. Beatty. (*E.W. & W.E.*, July, 1930, Vol. 7, pp. 361–366.)

The proposed numerical definition of selectivity is based on the relation between the change in frequency necessary to reduce the response to one-tenth of its resonance value, and the resonance frequency itself. The selectivity number is expressed in such a way, with the resonance frequency in the numerator and the change in frequency in the denominator, that it increases as the selectivity increases. For an acceptor or rejector circuit, it is 0.2 times the coil magnification m ($m = L\omega_0/R$); for a multi-stage r.f. amplifier with tuned grid and plate circuits, it is approximately 0.2 times the geometric mean of the "corrected" coil magnifications multiplied by the sum of the number of valves and the number of tuned circuits.

On an Easy Proof of the Formula for Cumulative Grid Rectification.—D. S. Kothari. *Indian Journ. of Phys.*, Vol. 3, No. 4, pp 499–502.)

The charge collected in the grid condenser in time t is directly proportional to $\frac{e^2}{4} \cdot \frac{d^2 I_g}{dE_g^2}$, where e is the impressed signal voltage. The discharge process is given by a potential curve with the exponent $-t/R$, where R is the whole combined resistance between grid and cathode. Finally the expression is arrived at for the anode current change (neglecting the grid-cathode capacity), namely:—

$$\triangle I_p = \frac{dI_p}{dE_g} \cdot \left[\frac{e^2}{4} \cdot \frac{d^2 I_g}{dE_g^2} \Big/ \left(\frac{1}{R} + \frac{dI_g}{dE_g}\right)\right].$$

Electrical Wave Filters.—M. Reed. (*E.W. & W.E.*, July and Aug., 1930, Vol. 7, pp. 382–386 and 440–445.)

Final two parts of the paper referred to in previous abstracts.

Applications of the Method of Alignment to Reactance Computations and Simple Filter Theory.—W. A. Barclay. (*E.W. & W.E.*, July, 1930, Vol. 7, pp. 376–381.)

Fifth and final part of the paper referred to in previous abstracts.

Über die Frequenzabhängigkeit von Widerstandskapazitatsverstärkern (The Dependence on Frequency of Resistance-Capacity Amplifiers).—H. Paul. (*Zeitschr. f. tech. Phys.*, June, 1930, Vol. 11, No. 6, pp. 203–206.)

The writer develops a formula for the voltage amplification of such an amplifier, from which can clearly be seen the decrease in amplification caused by the coupling condenser (C_c) and grid leak (r_g) for the low frequencies, and by the grid-cathode capacity (C_g) of the next valve for the high frequencies. "A properly designed resistance-capacity amplifier should display practically no frequency dependence; unluckily one finds very often that a blunder is made in the choice of r_g and C_c."

The writer, therefore, gives a "rule of thumb" recommendation that for the proper reproduction of the low frequencies, the product $C_c \cdot r_g$ should not depart far from 6.35×10^{-3} sec. It is these two factors which determine the potential distribution T, since if e_a is the anode potential and e_{g2} is the a.c. potential handed on to the grid of the following valve, the writer's formula is

$$T = \frac{e_{g2}}{e_a} = \frac{\omega \cdot r_g \cdot C_c}{\sqrt{1 + \omega^2 r_g^2 \cdot (C_g + C_c)^2}},$$

from which the effects at high and low frequencies are clear.

Matching Valve and Loud Speaker.—Sowerby. (*See under* "Acoustics.")

Caractéristiques des Lignes de Transmission Télégraphiques (Characteristics of Telegraphic Transmission Lines).—I. Constantinescu. (*Bull. Math. et Phys.*, Bucarest, No. 1, Vol. 1, pp. 65–67.)

The writer suggests that instead of the complex telegraph equations analogous to the characteristics of telephone lines, telegraph lines should be defined by two easily measured quantities: the relation $\beta = \sqrt{RG}$ and the difference between the propagation time of the fundamental frequency ω and the minimum propagation time for one of the partial frequencies of the signal:

$t = \left|\frac{d\alpha}{d\omega}\right|_{\omega} - \left|\frac{d\alpha}{d\omega}\right|_{\text{min.}}$, where α is the phase constant.

Radiation Resistance and Line Impedance: an Instructive Analogy.—G.W.O.H. (*E.W. & W.E.*, June, 1930, Vol. 7, pp. 297–300.)

Streuinduktivität, totale Induktivität und Gegeninduktivität (Leakage, Total and Mutual Inductions).—G. Hauffe. (*Helios*, No. 6, Vol. 36, 1930, pp. 45–46.)

A study of the inter-relations of the three types.

The Behaviour of Periodic Systems under Impulses at Different Intervals of Time.—A. K. Erlang. (*Fysisk Tidsskr.*, No. 6, Vol. 27, 1929, pp. 166–172: summary in *Physik. Ber.*, 15th May, 1930, Vol. 11, pp. 1021–1022.)

The writer finally applies his treatment of the question to the working of the "compensating impulse" in ballistic galvanometers, as used in La Cours' method for the measurement of the earth's field intensity.

TRANSMISSION.

Schwingungen in Dreielektrodenröhren mit positivern Gitter—Bemerkungen zu einer Arbeit von M.I.G. [M. J. O.] Strutt (Oscillations in Triodes with Positive Grid—Remarks on a Paper by M. J. O. Strutt).—H. E. Hollmann. (*Ann. der Physik*, 1930, Series 5, Vol. 5, No. 2, pp. 247–259.)

A critical examination of the results of a paper by M. J. O. Strutt on oscillations in triodes with positive grid voltage (see 1930 Abstracts, May, p. 274). The writer concludes that to regard the frequencies of a retarding field circuit as functions of the voltages alone can lead to no satisfactory results, unless the conditions of tuning both inside and outside the oscillating triode are considered as an important factor.

Zum Problem der Schwingungserzeugung in Elektronenröhren mit positivem Gitter (The Problem of the Production of [Ultra-Short Wave] Oscillations in a Valve with Positive Grid).—W. Kroebel. (*Zeitschr. f. Phys.*, 29th March, 1930, Vol. 61, No. 3/4, pp. 239–250.)

An experimental investigation of waves from 10 to 20 cms. in length produced with the Russian R5 valves used by Potapenko (March Abstracts, pp. 157–158). One particular object of the writer was to obtain good radiation: for this he used a half-wave dipole, with the condenser which bridged the ends of the grid and anode Lecher wires introduced at its mid-point. The Lecher wires were of telescopic copper tube and could thus be tuned to the oscillating zones of the valve. Another line of research was the investigation of the pigmy waves ("Zwergwellen") found by Potapenko: for this, the dipole was removed and Lecher wires of 1.8 mm. diameter used, supporting the condenser at their ends. Rigidity was given to these "wires" by the introduction of a violin gut under tension; it was impossible to prolong the wires beyond the condenser, since reflected waves were formed which interfered with the Lecher wire oscillations. The condenser was chosen of such a size as to present no resistance to the r.f. current: otherwise the voltage nodes and antinodes in the two wires were not equidistant from the condenser.

These tests showed that the *intensity of the pigmy waves increased to an extraordinary extent* (40–60 *times*) *when the anode was made definitely negative to the filament,* instead of being merely connected to its negative end. Under these conditions of increased energy, the anode current (which previous workers had regarded as an indication and even a measure of the oscillations) *became less than* 10^{-6} *A*.

The rest of the paper is devoted to the examination and explanation of this result. The explanation is based on the discovery that the grid circuit is responsible for fixing the frequency of the oscillations; the effect of negative anode voltage is to control the velocities of the electrons in such a way that the grid oscillations become freed from interference, thus increasing the grid control of the frequency and leading to the great increase in the intensity of the oscillations.

Über Mehrrohrschaltungen für sehr hohe Frequenzen (Multi-Valve Circuits for [Generation of] Ultra-high Frequencies).—A. Dennhardt. (*Zeitschr. f. hochf. Tech.*, June, 1930, Vol. 35, pp. 212–223.)

"Large" outputs have been successfully obtained for waves down to about 3 m. (Esau, Wechsung, Pistor; see also McArthur, 1929 Abstracts, p. 42). For still shorter waves (3 — 1 m.) either the ordinary reaction method or the B.-K. method is applicable, but on account of the larger outputs obtainable by the former (even compared with multi-valve circuits of B.-K. type) it is desirable to keep to this method down to the very limit of wavelength, and the writer therefore deals only with it. In view of previous multi-valve results of Holborn, Mesny, Kiebitz and Englund, he limits himself to waves from 1.5 m. downwards.

To reduce *L*, Kohl and Lakhovsky both used circuits inside specially designed valves, but the writer dismisses this plan as unsuitable for "large" powers. He points out how a reduction of *L* also involves a reduction of *C*, since the oscillating capabilities depend largely on *L/C* (Cords, 1928 Abstracts, p. 286). He gives a table of the internal capacities of certain valves ("Ultra," Te-ka-De and Telefunken) measured by Weihe's version of the Pungs and Preuner method (1929 Abstracts, p. 161); they depend largely on the arrangement of the electrode supports and of the connections to the socket. For waves below 2 m. he selected three types for their low capacities and high emission: *all three had oxide-coated filaments.*

He gives his reasons for adhering to push-pull or symmetrical circuits in preference to valve-paralleling arrangements, and describes his preliminary experiments with Holborn (derived from

Eccles) and Mesny push-pull circuits, using "normal" valves—*i.e.*, the types previously mentioned. His minimum wavelength was 1.34 m. To get still lower, he tried a "special" valve—the French TMC, in which the grid-cathode capacity was only 0.38 cm. compared with the 3 to nearly 5 cm. of the previous valves (though its other internal capacities seem to have been similar to those of the latter). Using a single-valve circuit due to Bergmann (1929 Abstracts, p. 43) he reached 1.2 m., but failed to get his expected further reduction by using a symmetrical two-valve circuit. It was this failure which led him to the study of reaction conditions which form section V of the paper, in which he deals with the reaction conditions valid for long waves (obtained by Barkhausen, Rukop, Alberti-Zickner, Herzog and others) and shows that they can be extended also to these ultra-short waves. He takes as the basis for this work the Huth-Kühn long wave transmitter circuit with internal reaction, and its ultra-short wave equivalent, which by duplication leads to the symmetrical ultra-short wave circuit finally adopted by the writer: it is, in fact, a modified Holborn circuit.

He now comes to the crucial point, on which all his further progress was based, of suitable choking in the filament circuits. He soon arrived at the use of one, or two, rejector circuits as chokes, thus agreeing with Bergmann, whose results are given in July Abstracts, p. 392. [For tuned chokes in filament leads of short wave transmitter valves, see also Patent by Esau, Feb. Abstracts, p. 99.] By this means he increased the range of possible oscillation of the transmitter both upwards and downwards: in the latter direction attained a wavelength of 80 cms.: and improved the energy conditions for all waves under 1.3 m., obtaining an output of 3 w. at a 90 cm. wavelength. The whole of section VI is devoted to these rejector circuits and their mode of action; since they have most effect at the limit of the zone of oscillation (where the phase relations are most unfavourable) it might be thought that their action was due to their improving these relations; but this explanation is rejected in favour of an action in preventing energy absorption and consequent damping—an interpretation supported by the fact that maximum output always occurs when the natural frequency of the rejector circuit agrees with that of the oscillator, which would not necessarily be the case if the action depended on phase adjustment.

The importance of these rejectors in the filament circuits, from the point of view of an ultra-short wave receiver, is pointed out. In the transmitter, they allow of a very gentle adjustment to the oscillation point, particularly with low anode voltages: applied to a receiver, this would be of great use. A somewhat similar effect could be produced by adjusting the filament current, but as this affects the frequency, the rejector adjustment is preferable.

As regards constancy of frequency under varying anode voltage and filament currents, the symmetrical Huth-Kühn circuit with internal reaction through the grid-anode capacity is pre-eminent, being greatly superior to the Mesny push-pull circuit or the Bergmann one-valve circuit. Filament current changes of ± 10 per cent. and anode potential changes of − 20 per cent. to + 30 per cent. produce a wavelength change of only 0.4 per cent.

Range tests, using Pistor's receiver (July Abstracts, p. 394) gave perfect telephony on a 95 cm. wave over 12 km., signals still being very loud at this distance. Modulation was by direct grid-potential control by l.f. transformer. Audio-frequency a.c. was employed as anode supply, to give tonic train telegraphy. "Communication depends on the transmitter being within the theoretical visual range."

In connection with the modified form of the Holborn circuit, the writer remarks that to get increased output he connected the neutral points of the grid and anode systems by a condenser, but this condenser does not appear in the diagram as stated. The frequency was hardly altered by this change. By the star connection around this condenser of other pairs of valves, "the possibility is offered of a theoretically unlimited energy-multiplication." Investigations on this point are not yet completed.

ERZEUGUNG KURZER ELEKTROMAGNETISCHER WELLEN MITTELS ZWEIGITTERRÖHREN (The Generation of Short Waves by Two-Grid Valves).—J. Sahánek. (*Schr. d. Naturw. Fak. d. Masaryk-Univ.*, No. 120, 1930, 16 pp.)

Czech, with English summary. An investigation of the case when the first grid is positive with regard to the cathode, the second having the potential of the mid-point of the cathode, while the anode has a lower potential than the cathode. The oscillatory circuit is connected across the two grids. As a result of the oscillating e.m.f. produced, a periodic distribution of the charge imposed on the second grid takes place there; part of it returns, the other part arrives behind the second grid, where it is subjected to the e.m.f. between this and the plate. This portion also then returns and reaches the space between the two grids. The writer calculates the intensity of this current and the energy it supplies to the circuit; this energy is added to that due to the current which reverses *before* reaching the second grid. The calculation shows that for a certain potential range between second grid and plate, the energy increases as compared with the three-electrode valve, and it is shown by experiment that this particular range occurs in the ordinary commercial two-grid valve. The paper ends with a discussion of the amplification of the oscillations found by Kohl when he replaced the plate of a triode by a grid (*Ann. der Physik*, Vol. 85, p. 30).

THE DIRECT CURRENT GRID METHOD OF MODULATION.—F. C. Lunnon. (*Marconi Review*, June, 1930, pp. 14–29.)

An investigation of the modulation method depending on the fact that if the driving voltage impressed on the grid of a magnifier valve is maintained at a constant amplitude and the grid bias is varied in magnitude, the resulting variations both of the d.c. input to the valve anode and of the efficiency of conversion to a.c. should, ideally, bear a linear relation to these grid bias variations. The filament-anode impedance of a small triode, used as a grid leak, provides these grid-bias variations; the microphone output, suitably amplified, being impressed on its grid.

It is found that as regards depth and linearity of modulation attainable, choke control and power amplifier methods are superior to this method; the latter, however, has great advantages for certain transmitters (naval, military, etc.) in which saving of space and ease of changing from c.w. to telephony or i.c.w. are more important than the attainment of perfect reproduction.

SHORT-WAVE SHIP'S TRANSMITTER.—M. Reed. (*Wireless World*, 25th June, 1930, Vol. 26, pp. 671–673.)

A description of a single-valve short-wave transmitter which has been installed in a number of vessels for world-wide transmissions between 17.5 and 48.8 metres. A simple Hartley circuit is used containing, in addition to the normal tuning condenser, a second condenser forming a bridge circuit with the valve grid-plate capacity and the tuning inductance. An adjustment can therefore be made to the second condenser so as to reduce the effective capacity introduced by the valve into the oscillator circuit, and hence to enable the valve to oscillate at a higher frequency than would otherwise be the case. The rest of the instrument is straightforward in design.

RECEPTION.

REJECTOR CIRCUITS IN FILAMENT LEADS OF ULTRA-SHORT WAVE RECEIVERS.—Dennhardt. (*See* abstract under " Transmission.")

SUPER-REGENERATIVE RECEIVERS FOR ULTRA-SHORT WAVES.—Stoye. (*See* abstract under " Propagation of Waves.")

SUPPRESSING IGNITION-INTERFERENCE ON RADIO-EQUIPPED AIRCRAFT.—E. A. Robertson and L. M. Hull. (*Journ. Soc. Autom. Eng.*, July, 1930, Vol. 27, No. 1, pp. 78–86.)

The writers consider that the methods of interference suppression in vogue to-day are the results of wholly empirical and, in many cases, unscientific development. A constructive tendency in recent shielding development, however, is the extension of the idea that a shielding system which holds together under service conditions, if intelligently designed, may be just as successful in keeping water, oil and dirt out of the ignition as it is in keeping noise out of the radio. The rest of the paper is devoted to a discussion and illustrations of various shielding systems now in commercial or experimental use, which are designed for *complete* housing of all important current-carrying circuits on the engine.

In the subsequent discussion, Eells considers that most of the applications of radio to aeroplanes will be simply the installing of long wave receiving equipment, and that it is not necessary to pay for the shielding necessary for 50 m. waves when all reception will be on 1,000 m. or thereabouts. Hoover believes that shielding as at present developed will not stand up under the continuous grind of transport operation: satisfactory shielding will be evolved slowly. C. Francis Jenkins describes tests with an unshielded nine-cylinder engine, and " does not believe that the engine builder should be charged with the task of the radio man."

ENGINE-IGNITION SHIELDING FOR RADIO RECEPTION IN AIRCRAFT.—Diamond and Gardner. (*Proc. I.R.E.*, May, 1930, Vol. 18, pp. 840–861.)

See July Abstracts, p. 393.

GRID OR ANODE RECTIFICATION? A PLEA FOR THE GRID RECTIFIER IN SETS DESIGNED FOR BROADCAST REPRODUCTION.—P. K. Turner. (*E.W. & W.E.*, July, 1930, Vol. 7, pp. 371–375.)

A paper by the designer of the new Amplion receivers. A discussion of a number of curves leads to his maintaining that the grid rectifier, *properly managed*, is inherently freer from wave-form distortion than the anode rectifier. He then briefly considers their comparative performance in other respects:—

1 and 2.—Variation of response to various radio frequencies and to various modulation frequencies; for a wave-range of more than 10 : 1, the grid-leak-condenser combination should be varied, but for reception on the two broadcast bands this is quite unnecessary: it is alleged that the grid-leak-condenser combination seriously cuts the high audio-frequencies, but it does *not*—up to 10,000—if properly chosen (the usual 0.0002 μF. and 3 megohms is " ridiculous "; with 0.0001 μF. and 0.5 megohm, the cut-off is negligible); in any case, the by-pass condenser in the anode rectifier can produce similar cut-off, and either type really calls for a properly designed filter in the anode circuit (as in the Amplion patent). 3.—Coupling to the audio amplifier—the grid rectifier is more convenient. 4.—Coupling to the r.f. amplifier: the anode rectifier causes much more damping than is generally believed, but still has the advantage over the grid rectifier. 5.—Retroaction—the parrot cry of " no reaction if quality is required " is foolish; it is completely justifiable to use a low-efficiency arrangement and bring its efficiency up to normal by reaction, and the grid rectifier lends itself admirably to this. 6.—Flexibility—the grid rectifier distorts less than the anode on inputs too weak for best results; on too strong an input, it is probably worse, but " both are so horrible that there is not much in it." 7.—Efficiency—although the usual claim of " enormous " superiority for the grid detector applies only to excessively weak signals such as may occur in telegraphy, for reasonable inputs the superiority is distinct (*e.g.*, 40–60 per cent. compared with 24 per cent.). 8.—Order of input required and output given—merely a matter of proportioning the r.f. and l.f. amplification to suit.

WAVE-FORM DISTORTION IN THERMIONIC VALVES.—Schäfer. (*See under* " Acoustics.")

OVER HET Z.G. "MICROFONISCH" EFFECT BIJ VERSTERKERS (On the so-called "Microphonic" Effect in Amplifiers).—E. Kaupa. (*Tijdschr. Ned. Radiogen.*, June, 1930, Vol. 4, No. 5, pp. 128–141.)

Author's summary :—In this article it is tried to give a theory of the "microphonic effect" and to show with the aid of this theory that there is no disturbance by this effect in the high frequency amplifier. The disturbance may be very troublesome in a low frequency amplifier. Some indications are given of methods to diminish the effect [not merely by mechanical considerations of rigidity but also by electrical considerations—based on the theory—as to the spacing of the electrodes, and as to the nature of the circuits used]. The theory is extended to the valve with more than 3 electrodes. For a particular case the author has given a simple connection for diminishing the influence of a particular part of the disturbing spectrum.

THE STENODE RADIOSTAT.—S. O. Pearson. (*Wireless World*, 21st May, 1930, Vol. 26, pp. 527–530.)

A description of the circuit used in Robinson's "Stenode Radiostat," together with a suggested explanation of the theoretical principles involved. The circuit is essentially that of a quartz crystal-controlled superheterodyne receiver with provision in the l.f. amplifier for frequency correction, which can be carried out by one of two methods. The first, described in *The Wireless World* of 19th December, 1929, introduces in the intermediate frequency stages a system of phase reversal to eliminate the effects of the long time-constant in the quartz resonator circuit. In the second and later method, no compensation whatever is provided in the high- or intermediate-frequency stages, but a special filter circuit is included between the first and second valves in the low-frequency amplifier. It consists essentially of a high-pass filter designed to have a frequency characteristic of such a shape as to compensate as nearly as possible for the excessive magnification of the lower modulation frequencies by the quartz resonator.

The writer offers the following as a possible explanation of the performance of the Stenode Radiostat in the light of the sideband theory. If a high-frequency wave of frequency f cycles per second is modulated so that its amplitude varies about the mean value at an audio-frequency of F cycles per second according to a simple sine law, it is well known that this modulated wave is equivalent to the sum of *three* high-frequency waves each having a constant amplitude and frequency. One of these has a frequency equal to that of the carrier wave, and the other two have frequencies of $f - F$ and $f + F$ cycles per second respectively.

When heterodyne interference is produced by an unwanted carrier wave setting up an audible beat note in conjunction with the carrier wave of the desired station, there are only *two* component high-frequencies involved. By adding two such waves together it can be shown that the resulting modulated wave does not have a constant frequency. In other words, when *two* high-frequency waves are added together the resulting wave is not only modulated as regards amplitude, *but as regards frequency also.*

THE NUMERICAL EXPRESSION OF SELECTIVITY.—Beatty. (*See under* "Properties of Circuits.")

POWER GRID DETECTION.—W. T. Cocking. (*Wireless World*, 7th May, 1930, Vol. 26, pp. 479–483.)

An article discussing the linear properties of the new power grid method of detection. "It would appear that to prevent amplitude distortion in the grid circuit it is only necessary to apply an input voltage of sufficient magnitude to ensure that, with the maximum depth of modulation ever used, the instantaneous peak voltages are never low enough to enter the curved portion of the characteristic. The requirement, therefore, is exactly the same as that for anode rectification, and the reason why grid detection is the better is that the curved portion of the grid-current curve is much shorter in comparison with the total available length of characteristic than is the case with the anode-current valve."

To avoid the distortion which generally follows attempts to obtain a large output from the grid rectifier, increased plate potential is used ; with the AC/HL valve (taken as an example), employing the usual h.t. voltage of 60, distortion occurs if the r.f. input is greater than about 0.25 volt peak, but with 100 volts h.t. the input can be about 1 volt before distortion becomes evident, and with 150 volts h.t. actually applied to the plate about 3 volts input can be accepted.

BADANIE ODBIORNIKA REAKCYJNEGO (Investigation of the Reaction Receiver).—J. Groszkowski and W. Struszyński. (*Wiadomości i Prace Inst. Radjotech.*, Warsaw, No. 1, Vol 1, 42 pp.)

In Polish, with French summary. The investigation is conducted on an electrical model of high power. The theory of the reaction receiver, with and without detection, is discussed, considering it as a self-exciting and separately excited generator. Conclusions are arrived at, based on the measurements taken, as to the choice of conditions favourable to the working of the receiver. Finally the questions of distortion and selectivity, and the consequent advantages of low loss circuits, are discussed.

THE DEPENDENCE ON FREQUENCY OF RESISTANCE-CAPACITY AMPLIFIERS.—Paul. (*See under* "Properties of Circuits.")

PRESENT DAY PORTABLES.—(*Wireless World*, 11th June, 1930, Vol 26, pp. 598–601.)

A survey of design in modern portable wireless sets. While no outstanding new feature occurs in 1930 models, an increase is noted in the use of the tuned r.f. stage in place of the all-aperiodic amplifier. Leaky grid detection is used in 99 per cent. of available sets ; provision for eliminator, 38 per cent. ; pentode output, 25 per cent. ; screen-grid valves, 38 per cent.

THE BAND PASS FILTER FOR LONG WAVES.—W. T. Cocking. (*Wireless World*, 18th June, 1930, Vol. 26, pp. 642–647.)

The design of r.f. amplifiers for use on the long-wave broadcast band having been somewhat neglected in recent years, the author deals with the means of adapting band pass filter methods as used on the normal broadcast band for reception on the lower frequencies.

That the tuning on long waves is comparatively flat is not an indication that sidebands are not being cut. The article describes the circuit conditions necessary for satisfactory sideband retention combined with the necessary degree of selectivity.

THE BAND PASS FOUR.—W. T. Cocking. (*Wireless World*, 25th June, 1930, Vol. 26, pp. 660–665.)

A home-constructor's four stage receiver designed in recognition of the fact that "the performance demanded of a modern wireless receiver is continually becoming more and more exacting." The specification includes :—Band pass filter tuning, two r.f. stages with a.c. screen-grid valves, power grid detection, push pull output (which balances out second harmonic distortion and removes to a very great extent residual hum), complete a.c. mains operation, single tuning control, volume control by high resistance potentiometer in r.f. circuit, and automatic grid bias control through voltage-dropping resistances.

PROVISION FOR THE ALTERNATIVE USE OF DIRECT (BATTERY) AND INDIRECT (MAINS) HEATING IN A RECEIVER.—(German Pat. 491886, Sachsenwerk, pub. 24th Feb., 1930.)

For the arrangement of resistances, plugs and sockets for this optional use of d.c. and a.c. valves, *see Zeitschr.f. hochf. Tech.*, June, 1930, pp. 238–239.

RÉCEPTEUR À SENSIBILITÉ ASSERVIE (Receiver with Automatic Control of Sensitivity).—H. de Bellescize. (*L'Onde Élec.*, June, 1930, Vol. 9, pp. 266–291.)

The writer first describes in detail his original well-known automatic volume-control circuit in which a mechanical relay, controlled by the rectified carrier-wave current, governs the amplification by adjusting the grid voltage of the preceding amplifier valve (French Pat. 628595, 1926; 1928 Abstracts, p. 519; *L'Onde Élec.*, 1927). He then discusses the precautions and refinements arrived at since then (P.V. 293050, 7th April, 1930), largely connected with obtaining perfect functioning of the relay, the reduction to a negligible strength of the second harmonic introduced by working the controlled valve on the curved portion of its characteristic, and the combating of the distortion occurring in deep and rapid fading.

In an appendix the writer discusses the Friis automatic control circuit, dispensing with mechanical relays (French Pat. 603373, 1925; U.S.Pat. 1675848); in this connection he refers to a patent of his own Company on the amplification of the signals applied to the auxiliary detector (667743, 1928). He ends with a relay-free circuit which he designed six years ago to combat parasites stronger than the signals (French Pat. 560208) but which he has now adapted to counteract fading; it is used on the Paris-Buenos Ayres receivers (Villem, July Abstracts, p. 410).

RADIO AT THE PARIS FAIR.—(*Wireless World*, 4th June, 1930, Vol. 26, pp. 578–579.)

Notes on a visit to the "Foire de Paris." The continuance in popularity of the superheterodyne in France was indicated throughout the show, originality being sought, not in circuit arrangements, but in the devising of ingenious tuning controls. Many of the sets shown would be regarded as competitive in price with British types, cabinet self-contained superheterodyne sets being available at prices ranging from £12 upwards.

POWER PENTODE-TWO.—W. I. G. Page. (*Wireless World*, 7th and 14th May, 1930, Vol. 26, pp. 474–478 and 498–503.)

A constructional article introducing a two-valve all-mains receiver employing a power grid detector and high-voltage pentode. A simple explanation is given of the principles of the high-voltage linear power grid detector. Owing to the large anode current flowing, it was found necessary to filter-feed the low-frequency intervalve transformer permitting frequency correction according to whether the primary is connected to assist or oppose the secondary. By autocoupling the transformer an enhanced step-up is obtained and the remarkable single l.f. stage amplification of about 135 is obtained. The theory of the pentode is discussed, and it is pointed out that when the dynamic characteristic is taken, the valve is seen to behave like a triode of some 6,000 ohms a.c. resistance with an a.c. undistorted output per volt grid-swing considerably greater than any three-electrode valve. A variable impedance eliminating device acting as a tone control is connected across the step-down output choke.

MARCONI MARINE SHORT WAVE RECEIVER, TYPE 372.—(*Marconi Review*, June, 1930, pp. 9–13.)

For wavelengths 14–100 m. It has three valves: a screen-grid valve between the oscillating detector valve and the aerial (to decrease to a minimum the energy radiated), and one note-magnifying valve.

AN ALL-SERVICE PORTABLE [SHORT-WAVE] RECEIVER.—H. A. Chinn. (*QST*, May, 1930, Vol. 14, pp. 39–41.)

Description of a 24–170 m. 3-valve receiver weighing 12 lbs. complete with batteries.

AERIALS AND AERIAL SYSTEMS.

REFLECTOR AERIAL SYSTEMS. — (German Pat. 492311, Scheller, pub. 21st Feb., 1930.)

Taking a single wire as the aerial and a curve of wires behind it as the reflector, the inventor points out that whereas the centre wire of the reflector can throw all the energy back in the right direction, the wires towards the side of the curve cannot do this, since they are more or less symmetrically placed (with regard to forwards and backwards) for the energy arriving from the aerial. He proposes to cure this defect by another curve of reflector wires behind the first reflector, and by two wires *in front of* the aerial to throw back the direct radiation from this, so that only one ray (that from the reflectors) results.

Elimination of Antenna Effect in Frame Aerials. — (German Pat. 491604, "Rad. Holland," pub. 15th Feb., 1930.)

The frame aerial is connected to earth on both sides of its condenser by two opposed coils with a common secondary leading to the amplifier. Signals due to antenna effect neutralise one another in the secondary, while those due to frame reception act additively.

Prevention of Stationary Waves in Feeders of Short Wave Aerials.—(German Pat. 491416, Radio Corp. of Am., pub. 10th Feb., 1930.)

A symmetrical connection of the two feeders to two points on the aerial such that the impedance of the portion between the points is equal to the characteristic impedance of each feeder.

Sur la Variation de l'Impédance équivalente d'une Ligne transmission en haute Fréquence (The Variation of the Effective Impedance of a Transmission Line at High Frequencies).—T. A. Tanasesco. (*Bull. Math. et Phys.*, Bucarest, No. 1, Vol. 1, pp. 67–71.)

A treatment of the superposition of direct and reflected waves by graphical-analytical methods.

Short Wave Space-Ray Receiving Aerial System with Several Aerials of Different Optimum Space-Ray Angles.—(German Pat. 489918, Telefunken, pub. 25th Jan., 1930.)

Designed to give consistent results in spite of variations in conditions of propagation, by widening the combined optimum angle.

High Wind Pressures on Tall Structures : a Study of their Magnitude and Probable Frequency.—A. Morris Thomas. (*World Power*, July, 1930, Vol. 14, pp. 23–32.)

Tech. Report Ref. F/T42 of the Electrical Research Association.

VALVES AND THERMIONICS.

Reducing the "Microphonic Effect" in Valves.—Kaupa. (*See* abstract under "Reception.")

Special 4-Electrode Valve with Greatly Reduced Inter-electrode Capacities, for Wavemeter Use.—Griffiths. (*See* Lucas abstract, under "Measurements and Standards.")

O poteriah na anode electronnoi lampi (On the Anode Power Loss in a Thermionic Valve).—E. S. Antseliovitch. (*Westnik Elektrotechniki*, Leningrad, February, 1930, Part I, pp. 74–76).

In Russian. In this article formulæ are derived giving the anode loss as a function not only of the anode current and potential but also of the proportion of the cycle during which the anode current flows, and of the phase shift due to the external load. The formulæ are derived on the assumption that a valve can be regarded as a pure resistance load, and therefore some of the special characteristics of the valve, such as the initial velocity of electrons, the non-uniform distribution of potential on the plate, etc., are neglected.

The Rôle of the Core Metal in Oxide-Coated Filaments.—E. F. Lowry. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, pp. 1367–1378.)

Author's abstract :—Temperature-power relations have been determined for numbers of oxide-coated filaments. Part of these filaments had cores of platinum—10% iridium and others had cores of "Konel," an alloy of nickel, cobalt, iron and titanium. Oxide-coated Konel is a much better radiator than oxide-coated platinum-iridium, which causes a considerable difference in their temperature-input power characteristics. Nevertheless, emission measurements show that oxide-coated Konel filaments yield higher electron emissions than oxide-coated platinum-iridium under the same conditions of filament power. Experimental proof is also given that these filaments need no activation other than the decomposition of the alkaline earth carbonates to oxides in vacuo. The enormous difference shown between the emission characteristics of these two types of oxide filament necessitates the conclusion that the core metal has a definite function other than simply a mechanical support for the alkaline earth oxides.

Suggested mechanism of thermionic emission from oxide-coated filaments. In order to account for this difference, a modification is suggested in existing ideas concerning the mechanism of emission from this type of cathode. This modification consists in assuming that the source of emission is the composite layer formed by occlusion of alkaline earth metal on the surface of the core and that the electrons emitted diffuse through the interstices in the oxide coating into the vacuous space. Argument is presented to show that this explanation will also account for other peculiarities in the behaviour of oxide cathodes. (1) The decay of emission during life may be explained by a slow sintering of the coating and a consequent closing of these pores. (2) Deactivation of the filament by over-heating may be attributed to the same cause. (3) Non-saturation may be due to a pseudo-space charge formed by occlusion of electrons on the surface of the coating particles.

The Function of the Base Metal in Oxide-coated Filaments.—E. F. Lowry. (*Phys. Review*, No. 1, Vol. 35, 1930, p. 121, Abstract only.)

Die Elektronenemission von Oxydkathoden (The Electronic Emission from Oxide Cathodes).—A. Gehrts. (*Zeitschr. f. tech. Phys.*, July, 1930, Vol. 11, No. 7, pp. 246–253.)

After discussing at length various earlier theories and the arguments on which they were based, the writer shows how he reaches his present conclusion, namely that the electronic emission from oxide-coated cathodes is a *thermionic* emission from metallic barium (or other alkaline earth metal) adsorbed in the interior and at the surface of a strontium oxide layer. The barium is formed in the metallic state by thermal dissociation of the barium oxide ; during the activating process, the oxygen set free is completely driven from the cathode.

By aiding this process in the following manner, the writer obtains an advantageous building up of the cathode, giving maximum emission and a high constancy of performance :—before activation, the cathode is " formed " by reaction with a readily oxidisable constituent (iridium, rhodium or nickel) blended with the material of the core.

Changes in the emission from oxide-coated cathodes, on the extraction of current and on changes of temperature, are explained by alteration of the thickness of the barium surface-films produced by to-and-fro diffusion of barium : after giving up conduction- or thermal-electrons, the barium becomes temporarily a positive ion, and as such is subjected to the effect of the field—which leads to " back-diffusion."

The Photoelectric and Thermionic Properties of Platinum Coated Glass Filaments.—A. K. Brewer. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, pp. 1360–1366.)

" The photoelectric and thermionic properties of platinum sputtered glass filaments are discussed, special attention being given to the effect of temperature, and to electrolysis of potassium through the glass to or from the sputtered coating."

On the Emission of Positive Electricity from Palladium.—Fr. Gulbis. (*Acta Univ. Latv.*, Mat. Ser. 1, No. 3, pp. 51–68.)

The writer's results in no way agree with the Richardson formula $i - i_0 = A.c^{-Kt}$, but correspond exactly to the equation $i \,.\, t = K =$ const. There is no regeneration in dry air or hydrogen, but if the wire is dipped in an electrolyte, there is great emission, the new curves being steeper.

Phase Theory in Thermionics.—O. Halpern. (*Ber. Akad. Wiss. Wien*, 1929, pp. 625–627 ; summary in *Science Abstracts*, Sec. A, May, 1930, p. 524.)

" A metal is considered to be a two-component system consisting of ions and electrons. On this basis it is shown that contact potentials are to be expected at transition points."

Characteristic Energy Losses of Electrons Scattered from Incandescent Solids.—E. Rudberg. (*Proc. Roy. Soc.*, April, 1930, Series A, Vol. 127, No. A804, pp. 111–140.)

DIRECTIONAL WIRELESS.

The Marconi-Adcock Direction Finder.—N. E. Davis. (*Marconi Review*, June, 1930, pp. 1–8.)

(1) Introductory : — Abnormal polarisation : " night effect " : " aeroplane effect." (2) The 1919 Adcock patent—the arrangement of the horizontal lead-in from each aerial in such a way that any e.m.f. induced by the unwanted component should be balanced out by virtue of the equal and opposite electrical configuration of this portion of the circuit : reasons why the system did not immediately develop commercially. (3) The Smith-Rose Barfield modifications (1926) with raised receiving hut. " The results obtained confirmed that bearings of a very high order of accuracy were recorded under all conditions of day and night " (*see* 1929 Abstracts, pp. 332–333). Their later design, in which the hut containing the radiogoniometer is situated at ground level (July Abstracts, pp. 397–398). (4) T. L. Eckersley's design (*Journ. I.E.E.*, Aug., 1929) with buried cables ; and the form finally adopted, with the leads shielded in copper tubes running about 2ft. above the ground.

The importance of the system for aiding aircraft at night is illustrated by a graph showing simultaneous records, on a loop and on the Marconi-Adcock system, of the position of an aeroplane transmitting with long trailing aerial on 930 m., one hour after sunset.

Les Procédés radio-électriques pour le Guidage des Navires et des Aeronefs (Radio-electric Systems for Guiding Ships and Aircraft).—P. David. (*L'Onde Élec.*, May, 1930, Vol. 9, pp. 197–228.)

A comprehensive survey. The writer deals in succession with fixed (land) d.f. stations, their advantages and disadvantages : d.f. equipments on board the vessel, starting with the ordinary radiogoniometer and passing on to direct-reading arrangements (" Hertzian compass "), particularly that of Busignies (1927) in which a cardioid combination rotating at about 10 turns per sec. carries with it the field-magnet of a galvanometer. This galvanometer has enough inertia to integrate the current during each revolution, so that the pointer indicates the position of the transmitting station from 0° to 360° " without any ambiguity and with an excellent precision (two degrees)." This apparatus will be described in detail in a later article : it will probably be put into regular service very soon.

Hell's somewhat similar system (March Abstracts, p. 161) is referred to, and then the writer passes on to the systems using a rotating directional transmitter, referring particularly to the work of Smith-Rose and Barfield and the 6 metre Marconi beacons. The stationary directional transmitter is then dealt with : first the equi-signal beacon as evolved in the U.S.A., and in France for the guidance of aircraft on the Paris-London route. " From the point of view of aircraft, it is difficult to find a superior, and the system appears very attractive." One great objection is the interference produced in the neighbourhood by the modulated c.w. transmissions—" the Americans already are having trouble with this."

The writer then refers enthusiastically to the Aicardi system (1929 Abstracts, p. 332) with which he deals rather fully. Results with ships at Havre (since 1927) and with aircraft at Saint Cyr show that the accuracy is of the order of 1 degree at distances up to 60 or 80 km.

The second part of the paper deals with the tracing of curved routes and the determination of distance. Regarding leader cables, Bourgonnier is quoted as saying that the first large scale use of these was by Germany about 1917 for the guiding of submarines, " but we have been unable to trace any definite documentation as to this." The work of Loth on these lines, both for ships and aircraft, is dealt with (Jan. Abstracts, pp. 47–48 ; Feb., p. 104) ; also his systems using crossed beams (light, supersonic or radio—*see* April Abstracts, p. 217). Regarding distance determination, the writer mentions Pérot's system for maintaining intervals between ships in the same convoy by measuring the intensity of the magnetic field (*L'Onde Élec.*, 1923, pp. 193–199) ; Burstyn's proposals (1929 Abstracts, p. 453) ; and finally acoustic methods (Marti in France and Wood and Brown in England, 1922 and 1923.) No reference is made to the recently inaugurated foghorn-wireless system on the Clyde (Feb. Abstracts, p. 117). The paper ends with a bibliography of 64 references.

AERONAUTIC RADIO BEACON IMPROVEMENTS.—U.S. Bureau of Standards Notes. (*Journ. Franklin Inst.*, June, 1930, Vol. 209, No. 7, p. 834.)

A note on recent work at the Bureau on the characteristics of the vibrating reed course indicator, using a high-permeability nickel-steel alloy, " A " metal.

A small filter unit has been designed to permit the simultaneous connection of the reed indicator and the head telephones in the receiving set output.

ACOUSTICS AND AUDIO-FREQUENCIES.

DER TONFILM (The Sound Film).—K. Petsch. (*Elektrot. u. Masch : bau*, 19th Jan., 1930, Vol. 48, pp. 59–64.)

A survey dealing briefly with the earlier methods and more fully with recent systems. A rather full discussion is given of the nature and the comparative merits and demerits of the " transverse " and " intensity " methods : it is shown that the former is inclined to need a greater width of strip and is therefore hard to introduce into the standard film, while on the other hand it needs none of those exact gradations of light and shade which are required with the latter system and which lead to considerable complications (*e.g.*, the recording of sound and picture on separate films, each best suited in respect of contrast, and the final combining of the two into a common film).

A good deal of space is given to the Austrian " Selenophon " system (Thirring and Richtera) which uses the transverse method, recording by a string galvanometer device. The thread, about 1/10 mm. in diameter and 20 mm. long, is stretched so tightly that its natural frequency is of the order of 15,000 p.p.s. It lies in an air gap about 0.6 mm. wide in a very powerful magnetic field, the poles of the electromagnet being pierced with a hole in which a system of lenses is fitted, throwing the image of a long narrow slot. The thread crosses the slot *at a fine angle* so that when at rest it prevents half the image of the slot from reaching the film, and a very small movement covers or uncovers a considerable length of the slot.

Reproduction is by means of the Thirring selenium cell. The inertia of selenium cells (ordinarily shown by decreasing amplitudes at higher frequencies, and consequent distortion) is compensated for by a resistance-capacity coupling with a small capacity—100 to 200 cm.—to the grid of the first valve. Background noise is reduced below audibility, and the light-sensitive surface is made so small that the rays may be brought to a very sharp focus on it. The efficiency is increased in these ways to such a point that small light intensities and few amplifying stages are sufficient.

The " Selenophon Junior " is a " home " gramophone using 6 mm. film, or paper band like Morse strip. 300 m. gives a run of 40 minutes (as many as four record-lines being crowded into the 6 mm.) while better quality, longer life and smaller cost are additional advantages here claimed over the ordinary disc record.

THE " SELENOPHON " SYSTEM.—K. Petsch. (*See* above abstract.)

THE GENERATION OF SOUND BY THE SIREN PRINCIPLE.—E. Simeon. (*Proc. Physical Soc.*, 15th June, 1930, Vol. 42, Part 4, pp. 293–299.)

The production of a steady note at good strength is quite a simple matter, but to range over six or seven octaves with any certainty as to relative intensity is a good deal more difficult. The writer discusses various undesirable features of the simple siren and goes on to describe a siren of his own design which has a reasonably pure note whose intensity can be kept constant throughout a range of pitch from about 70 to about 7,500 p.p.s. Smoothness of running is obtained by the introduction of an artificial load (rearward radiation 180° out of phase) between the intervals of useful sound generation through the forward holes.

EIN NEUES AUTOMATISCHES VERFAHREN DER NACHHALLMESSUNG (A New Automatic Method of Measuring Echoes).—E. Meyer. (*Zeitschr. f. tech. Phys.*, July, 1930, Vol. 11, No. 7, pp. 253–259.)

A substitute for the usual oscillographic methods, which are undesirably complicated especially when a number of measurements have to be made—*e.g.*, for investigations of absorbing materials. By the use of a combination of a valve amplifier and either a glow-discharge tube or a valve relay circuit, a relay is controlled which governs a stop-clock, so that the latter records the echo-time directly in seconds.

Difficulties encountered with the glow-discharge tube, which displayed hysteresis effects causing irregularity in functioning, were overcome by introducing into its circuit an a.c. voltage of about 1 volt at 50 p.p.s. The tube then worked with great precision, extinguishing itself always at the same d.c. potential.

The alternative valve relay device consists essentially of a small 100 m. oscillator, normally prevented from oscillating by a strong negative bias. It is considerably more sensitive than the glow-discharge tube ; it "almost" enables the "Sabine-time" (time for a decrease to 1/1,000 of initial amplitude) to be measured. The paper ends with several results obtained ; curves are given for the effect of dampness of the air on echo-times at high frequencies, etc.

Absolute Geschwindigkeitsmessungen mit Hitzdrähten in stehenden Schallwellen (Measurements of Absolute Velocity by Hot Wires in Standing Sound Waves).—H. Müller and E. Waetzmann. (*Zeitschr. f. Phys.*, 21st May, 1930, Vol. 62, No. 3/4, pp. 167–179.)

Optimum Reverberation Time for Auditoriums.—W. A. MacNair. (*Journ. Acoustical Soc. America*, Jan., 1930, Vol. 1, No. 2, Part 1, pp. 242–248. ; *Bell Tech. Journ.*, April, 1930, Vol. 9, No. 2, pp. 390–397.)

"A presentation of a logical basis for the variation of reverberation time with frequency and reverberation time with the volume of acoustically good auditoriums."

The Improvement of the Audibility of Speakers by Sound Reflectors.—M. Nuyens and G. Th. Philippi. (*Physica*, No. 1, Vol. 10, 1930, pp. 19–26.)

The Effect of Reverberation Time in the Reproduction of Sounds.—E. A. Johnson. (*Journ. Math. Phys.*, No. 1, Vol. 9, 1930, pp. 1–10.)

The Balsa Wood Diaphragm Loud Speaker.—(*Wireless World*, 25th June, 1930, Vol. 26, p. 673.)

The results of comparative tests conducted by *The Wireless World* with a loud speaker of the type described by R. W. Paul in the issue of that journal for April 9th, 1930 (May and July Abstracts, pp. 282 and 400.)

As might be expected from the published frequency characteristics, the loud speaker is at its best when reproducing frequencies in the middle and upper—*i.e.*, from 750 cycles upwards, and by comparison the band from 750 cycles downwards is deficient. In the particular instrument tested, however, frequencies between 50 and 100 cycles appeared to be better reproduced than those between 100 and 500 cycles.

Some clue to the reason for the comparatively low acoustic efficiency in the lower register was obtained by visual observation of the diaphragm. There can be no doubt that the moving coil is developing the requisite amplitude at low frequencies ; movements up to ¼in. or ⅜in. are of common occurrence. But it is equally apparent that the diaphragm is not acting as a perfect piston at low frequencies, as it is intended to do. Even in the neighbourhood of 250 cycles, differences in amplitude at different points on the circumference of the disc are easily detected by the eye. Now the reproduction of high frequencies is dependent upon the breaking up of the piston into different modes of vibration. The trouble would appear to be that this process is carried too far into the bass, and it is understood that this is being investigated with the aid of Chladni dust figures, with a view to a possible revision of the arrangement of the stiffening ribs.

The Loud Speaker Diaphragm. N. W. McLachlan. (*Wireless World*, 4th June, 1930, Vol. 26, pp. 586–588.)

A discussion of the radial velocity of sound in a conical diaphragm, arising out of a previous article in *The Wireless World*, July 17th, 1929 ("The Breaking Up of Loud Speaker Diaphragms.") In order to obtain data relating to the velocity of propagation in a conical diaphragm, measurements were made by means of dust figures. A series of rings was traced by lycopodium powder between a circle about 4in. radius from the centre and the periphery, the rings representing nodes. The results are tabulated. At 1,600 cycles the nodal circles are accompanied by radial nodes, and the mean distance between two consecutive circles is 2.2 cm. This is the half-wave length, so that the whole wavelength = 4.4 cm., and the velocity of propagation is 1,600 × 4.4 = 7,000 cm. per second, or 230ft. per second. The velocity of sound at 20° Centigrade is about 1,200ft. per second. Thus the velocity of flexural waves down the outer part of the diaphragm at a frequency of 1,600 cycles per second is about one-fifth the velocity of sound in air. This leads to a very important result :—The time taken for sound to arrive at a point 4ft. from the apex of the cone, due to vibration of the apex, is the same as that for the flexural wave to reach the periphery of the cone ($f = 1{,}600$). Moreover, the sound from the periphery will reach the said point about $\frac{4}{1{,}200} = 1/300$th sec. later than that from the apex. When f is 1,600 cycles per second, 1/300th second is equivalent to $\frac{1{,}600}{300} = 5.33$ cycles. Thus the sound from the periphery will be 5.33 cycles late. Sound from areas lying between the apex and the periphery will be late by amounts varying from 0 to 5.33 cycles.

The Velocity of Propagation of Longitudinal Waves in Liquids at Audio-Frequencies.—L. G. Poole. (*Phys. Review*, 1st April, 1930, Vol. 35, No. 7, pp. 832–847.)

Beiträge zur Raumakustik (Contributions to Our Knowledge of Space Acoustics).—W. Linck. (*Ann. der Phys.*, Series 5, 1930, Vol. 4, No. 8, pp. 1017–1057.)

Beiträge zur Raumakustik (Contributions to Our Knowledge of Space Acoustics).—W. Kuntze. (*Ann. der Phys.*, Series 5, 1930, Vol. 4, No. 8, pp. 1058–1096.)

The Scattering of Sound-Waves by Small Elastic Spheres [Mathematical Investigation].—K. F. Herzfeld. (*Phil. Mag.*, May, 1930, Series 7, Vol. 9, No. 59, Supplementary No., pp. 741–751.)

The Propagation of Sound in Suspensions [Mathematical Investigation].—K. F. Herzfeld. (*Phil. Mag.*, May, 1930, Series 7, Vol. 9, No. 59, Supplementary No., pp. 752–768.)

The Words and Sounds of Telephone Conversations.—N. R. French, C. W. Carter, Jr., and W. Koenig, Jr. (*Bell Tech. Journ.*, April, 1930, Vol. 9, No. 2, pp. 290–324.)

This paper presents data concerning the vocabulary and the relative frequency of occurrence of the speech sounds of telephone conversation.

The Analysis and Measurement of the Noise Emitted by Machinery: Discussion.—Churcher and King. (*Journ. I.E.E.*, June, 1930, Vol. 68, pp. 780–787.)

Discussion on the paper dealt with in April Abstracts, p. 220.

Über die Formverzerrungen bei Elektronenrohren (Wave Form Distortion in Thermionic Valves).—E. Schäfer. (*Physik. Ber.*, 1st May, 1930, Vol. 11, pp. 898–899.)

Long abstract of a Dresden Dissertation on the acoustic distortion produced in amplification and rectification by valves. The distortion was measured by the voltage components of the overtones in percentages; the measurement was effected as follows:—a pure sinusoidal voltage was applied to the valve under test, so that a no longer sinusoidal current flowed in a resistance in the anode circuit. The fundamental was removed by the opposition of a sine wave voltage exactly equal to the output voltage, and the voltage of the remaining harmonics was measured, after amplification, by a thermo-element. The harmonics were dealt with one by one by means of an adjustable resonant circuit in the amplifier.

In amplification, for correct grid bias and working on the straight part of the curve the distortions are very small (under 1.5 per cent.); neglecting these conditions, and with wrong filament heating, they may greatly exceed 20 per cent.; they are greatest for zero grid bias—when they are only small if the internal resistance of the generator is very small. In the rectification of modulated h.f. (audion) the distortion is indicated by the $\triangle I_a/\mathfrak{E}_{g\ eff}$ curve. For anode rectification, the distortion is only dependent on the degree of modulation of the transmitter. Thus for deeply modulated transmitters, anode rectification is not suitable. The conditions are better in grid rectification, but here the shunting condenser of the leak (which may be 1 — 2 megohms) must not be greater than 100 cm. (*cf.* Turner, under "Reception.") It was found that the distortion was greater for small grid voltages. In this connection, the question of a h.f. grid bias is discussed.

Matching Valve and Loud Speaker.—A. L. M. Sowerby. (*Wireless World*, 28th May, 1930, Vol. 26, pp. 548–551.)

An article explaining why the knowledge of the d.c. resistance of a loud speaker is of no use when attempting to fulfil the recognised condition that the impedance of the speaker must be double that of the output valve to provide the maximum output of which the valve is capable. Curves are given showing that the moving-iron speaker has a different impedance for every musical frequency. It is best to aim at matching speaker and valve somewhere round middle C. The article concludes with notes on the design of the output stage for a pentode.

Über den von E.G. Richardson Entdeckten "Annulareffekt" (On the "Annular Effect" found by E. G. Richardson).—T. Sexl. (*Zeitschr. f. Phys.*, 8th April, 1930, Vol. 61, No. 5/6, pp. 349–362.)

Richardson found, in investigating the amplitudes of air vibrations in Helmholtz resonators, that contrary to all expectations the amplitudes did *not* reach their maximum in the central parts but in a layer near the wall, sinking to zero at the wall itself. It is here shown that the empirical formulæ derived in connection with this phenomenon all follow from the Stokes-Navier equations in hydro-dynamics.

The Behaviour of a Carbon Microphone.—Müller-Brünn: R. Führer. (*E.N.T.*, March, 1930, Vol. 7, pp. 130–131.)

Argument on the second writer's paper (Feb. Abstracts, p. 106) in which he contradicts the usual assumption that for a constant supply and excitation a carbon microphone behaves as a current source of constant e.m.f.

Piezoelectric Microphone.—Telefunken Co.: Meissner. (*See under* "Measurements and Standards.")

The Natural Frequency of a Rod Clamped at One End: Criticism.—Th. Pöschl: Esau and Hempel. (*Zeitschr. f. tech. Phys.*, June, 1930, Vol. 11, No. 6, pp. 220–221.)

Criticism of the work by the last two writers referred to in May Abstracts, p. 282.

The Absolute Measurement of Telephone Apparatus.—P. Chavasse and J. H. Gosselin. (*Ann. des P.T.T.*, Feb., 1930, Vol. 29, pp. 145–154.)

Piezoelectric methods are used both for transmitting and receiving. The microphones and telephones dealt with are those connected with international telephony.

Über die Schwingungsformen von Geigenkörpern (On the Form of the Vibrations of Violin Bodies).—H. Backhaus. (*Zeitschr. f. Phys.*, 21st May, 1930, Vol. 62, No. 3/4, pp. 143–166.)

Les Ondes stationnaires ultra-sonores rendues visibles dans les Gaz par la Méthode des Stries (Stationary Supersonic Waves made visible in Gases by the Method of Striæ).—E. P. Tawil. (*Comptes Rendus*, 16th July, 1930, Vol. 191, pp. 92–95.)

An application of interference-fringe methods to the observation of supersonic waves. The results of numerous tests do not agree with the values for the velocity of propagation of supersonic waves given by other workers. Thus for $\lambda = 3.75$ mm. in air, $V = 345$ m. [per sec.]. The writer envisages the application of the method to television, but no detailed suggestion is given.

An Interference Refractometer for Investigation of Sound Fields.—Martens. (*See* abstract under " Subsidiary Apparatus.")

Auditory Nerve Currents.—C. Foà and A. Peroni. (*Acc. Naz. d. Lincei*, 3rd Nov., 1929, Vol. 10, pp. 389–392.)

Using the auditory nerves of reptiles, the writers found that with organ pipe notes of 16, 33 and 132 p.p.s. the electric response was always intermittent, with a frequency of 50 to 60 per sec. But *cf.* Wever and Bray, Aug. Abstracts, p. 459.

PHOTOTELEGRAPHY AND TELEVISION.

Bemerkungen über die elektrischen Schwingungen in den Photozellen und ihre Anwendung bei den Lesemaschinen für Blinde (Remarks on Electrical Oscillations in Photoelectric Cells, and their Use in Reading Machines for the Blind).—B. L. Rosing. (*Zeitschr. f. tech. Phys.*, June, 1930, Vol. 11, No. 6, pp. 177–182.)

Amplified German version of the Russian paper dealt with in May Abstracts, p. 273. The circuit consists of a photoelectric cell in series with a source of h.t. and a resistance shunted by a condenser. As regards practical possibilities, the sensitivity is indicated by the fact that " signals, *i.e.*, note changes in the oscillations, are obtained if the illumination of the light-sensitive surface of the cell amounts to 0.1 lux. The oscillations are extinguished for 0.3 lux." The writer has applied the latter phenomenon to two devices for the blind, the first an aid to orientation as regards the surroundings, the second a reading machine [*cf.* Fournier d'Albe's " Optophone "]. " By means of a simple scanning device the characters are transformed into a series of long and short signals [in telephones] similar to the Morse alphabet."

Increasing the Brightness of Television Reception. (German Pat. 490578, Telefunken, pub. 30th Jan., 1930.)

Instead of the usual Nipkow disc, a rotating wheel is used carrying cylindrical lenses on its circumference : these lenses concentrate the light from a long glow-discharge tube which lies parallel to the axis of the wheel.

A Flexible Mirror for Light Control in Television. (German Pat. 492080, Holweck, pub. 18th Feb., 1930.)

The basis of the mirror is a very thin (less than 0.1μ) skin of celluloid or other material, obtained by a special process and made reflecting by a coating of (*e.g.*) magnesium. The shape of this mirror is altered by an electrostatic field, which thus alters the convergence of a ray of light reflected from it.

Königswusterhausen Television Transmissions. —(*Engineer*, 4th July, 1930, Vol. 150, p. 11.)

On 26 kw. (as compared with 1½ kw. at Witzleben), these programmes are taking place from 9 to 9.30 a.m. and 1 to 1.30 p.m., except Tuesdays and Thursdays ; it is probable that nightly tests after broadcasting hours will soon be started.

The Fading and Distortion of Distant [Television] Signals.—Dinsdale. (*See under* " Propagation of Waves.")

Die Anwendung des Kerreffektes zur Untersuchung der Verteilung des elektrischen Feldes in Dielektriken, und die Bestimmung einiger Kerrkonstanten (The Use of the Kerr Effect in the Investigation of the Distribution of the Electric Field in Dielectrics ; and the Measurement of some Kerr Constants).—G. J. Dillon. (*Zeitschr. f. Phys.*, 8th April, 1930, Vol. 61, No. 5/6, pp. 386–393.)

By the method described, the electric field distribution in nitro-benzol was investigated. For constant current, the field was found to vary very much, being about twice as strong at the cathode as at the anode. For a.c., the field near the electrodes was rather stronger than in the middle. *Cf.* R. Möller, *Physik. Zeitschr.*, Vol. 30, pp. 20–24.

In the second part of the paper, measurements are described of the Kerr constants of benzol and of benzol solutions of certain fluid-crystalline materials : the values for the solutions and for the solvent differed very little.

Improvement in Kerr Cells.—(German Pat. 492584, Karolus, pub. 22nd Feb., 1930.)

The plan of maintaining the dielectric strength of the medium by applying a constant d.c. potential to the plates of the condenser has the objection of introducing subsidiary capacities which decrease efficiency. According to the invention this cleansing potential is applied to the liquid by a pair of auxiliary electrodes.

Fluctuation Theory Applied to the Kerr Effect.—Didlaukies. (*See* abstract under " General Physical Articles.")

Über die Abhängigkeit einiger elektrischer und elektrooptischer Konstanten vom Nitrobenzol und Nitrotoluol vom Reinheitsgrade (On the Dependence of some Electrical and Electro-optical Constants of Nitrobenzol and Nitrotoluol on the Degree of Purity).—W. Ilberg : F. Hehlgans. (*Zeitschr. f. tech. Phys.*, July, 1930, Vol. 11, No. 7, pp. 283–285.)

Argument on the second writer's results (March Abstracts, p. 164).

The Photoelectric and Thermionic Properties of Platinum Coated Glass Filaments.—Brewer. (*See under* " Valves and Thermionics.")

Electrolysis of Potassium through Glass.—Brewer. (*See* above.)

Die lichtelektrischen Eigenschaften von Thalliumzellen (The Photoelectric Properties of Thallium Cells).—R. Sewig. (*Zeitschr. f. tech. Phys.*, July, 1930, Vol. 11, No. 7, pp. 269–273.)

An experimental comparison between thallium cells made by the Osram Company and certain other semi-conductor cells—namely a Case " Thalofide " cell, a " Selenophon " cell (Thirring of Vienna—*see* Petsch, under " Acoustics ") and a " Radiovisor " selenium cell. All the thallium cells showed an almost linear variation of conductivity with illumination, the slope only decreasing somewhat for high illumination—over 200 metre-candles (Hefner) ; whereas the selenium cells showed great resistance variation for weak illumination but became considerably less sensitive for strong.

Other results for the thallium cells were :—conductivity in the dark vanishes at low temperatures, increases slowly with increasing temperature and begins to mount steeply at 40°. Between resistance in the dark and potential there is a logarithmic relation. The increase of current following sudden illumination takes place, under normal conditions, in at most 0.01 sec. All the thallium cells have their maximum sensitivity for wavelengths between 1.05 and 1.1μ.

Die Erhöhung des lichtelektrischen Effektes von Kalium durch Wasserstoff (The Increase of the Photoelectric Effect of Potassium by Hydrogen).—R. Fleischer and H. Teichmann. (*Zeitschr. f. Phys.*, 29th March, 1930, Vol. 61, No. 3/4, pp. 227–233.)

Researches are described leading to the conclusion that for the formation of a highly sensitive layer in a Potassium-Hydrogen cell the simultaneous presence of potassium vapour and molecular hydrogen is essential ; the formation of the layer proceeds the more quickly, the higher the pressure of the potassium vapour. If, after distillation, a potassium cell filled with hydrogen at low pressure is left to itself at the temperature of the room, the increase of sensitivity can only proceed very slowly.

Effect of Red Light on Stopping Potentials of Photoelectrons Liberated by Blue Light.—A. R. Olpin. (*Phys. Review*, No. 1, Vol. 35, 1930, pp. 112–113.)

Referring to Marx' results (Jan. Abstracts, p. 51 ; *see also* Aug. Abstracts, p. 460), the writer considers that the effect is not a true one and can be explained by the photoelectric sensitivity of the anode, which generally is more sensitive to red light than the cathode ; if therefore stray light falls on the anode, the observed effect must occur. He describes an experiment confirming this.

Sur une Cellule photo-électrique pour l'Ultraviolet : Procédé de Sensibilisation (A Photoelectric Cell for Ultra-violet Light : Method of Sensitisation).—H. Hulubei. (*Comptes Rendus*, 30th June, 1930, Vol. 190, pp. 1549–1552.)

The writer has developed a method of sensitisation, by active hydrogen, *without using a discharge with the sensitive surface as one electrode.* The surface is exposed to the action of atomic hydrogen prepared either by Wood's method (where it is collected from the middle of a very long discharge tube) or by that of Franck and Cario (using excited mercury atoms to dissociate the hydrogen molecule). At present the writer has used palladium, but preliminary tests on potassium suggest that the method can be applied to the alkali metals.

Possible Application of the Interference-Fringe Phenomenon, and the Formation of Striæ, to Television.—Tawil. (*See* abstract under " Acoustics.")

La Mécanique des Photons (The Mechanics of Photons).—V. Fock. (*Comptes Rendus*, 16th June, 1930, Vol. 190, pp. 1399–1401.)

The writer treats the Maxwellian equations as the wave equation corresponding to the motion of a photon (light quantum) and develops on this basis the mechanics of a photon.

La Distribution dans l'Espace des Directions initiales des Photoélectrons (The Distribution in Space of the Initial Directions of Photoelectrons).—P. Auger. (*Helvet. Phys. Acta*, No. 4, Vol. 2, 1929, pp. 275–277.)

A survey of the experimental and theoretical work of various workers, including the writer (*cf.* 1929 Abstracts, pp. 285, 515).

MEASUREMENTS AND STANDARDS.

Some Developments of the Piezo-Electric Crystal as a Frequency Standard.—H. J. Lucas. (*Journ. I.E.E.*, July, 1930, Vol. 68, pp. 855–872.)

The full paper, with Discussion, a summary of which was dealt with in June Abstracts, pp. 343–344. In the discussion, Warrington-Morris asks if there are other reasons, besides the high temperature coefficient, for the writer's dislike of the transverse mode, and whether he can give any information as to the direct use of the longitudinal mode on short waves without frequency multiplication. The writer replies, giving as additional reasons (i) the production of spurious frequencies near the fundamental, due to the coupling of this and other modes of vibration, and (ii) the impossibility of obtaining nodal support. In reply to the second question, he states that it has not been found possible to make satisfactory longitudinal crystals having a frequency above 300 kc. per sec.

Referring to the Williams circuit mentioned in the previous abstracts, Dye considers that it would be difficult to keep the systems in step with the crystal over the long periods of time essential in checking absolute frequency measurements against some other time standard, "but the system is evidently worthy of further investigation and development." Referring to the writer's use of the crevasses, he says that this method is most valuable for determining the damping and elucidating the equivalent networks for oscillators or resonators, but that it is not the most suitable for determining, or setting a source to, the precise frequency of resonance; he describes a method depending on plotting the curve of the current in a small inductance across a small condenser (300$\mu\mu$F.) paralleled with the resonator, a practically constant e.m.f. of changing frequency being applied by way of the inductance. The frequency of resonance lies on the central, steeply-falling, part of this curve, and he gives the graphical construction for finding the exact spot. A setting to about 1 part in 10 million can be made if desired.

Griffiths, describing a sub-standard generator, refers to a 4-electrode valve specially made so that the interelectrode capacity is reduced to such a value that a slight relative displacement of the electrodes will not affect the accuracy of the wavemeter; using this valve as a negative resistance associated with the simple resonant circuit of the sub-standard, the wavemeter is practically independent of quite large changes in the potentials of the valve electrodes, and of the filament current. The frequency has remained constant to 2 or 3 parts in 10^6 for 12 hours in a room of varying temperature.

NEW FUNDAMENTAL FREQUENCY STANDARD.—U.S. Bureau of Standards Notes. (*Journ. Franklin Inst.*, June, 1930, Vol. 209, No. 6, pp. 833, 834.)

A short note on a new frequency standard equipment recently installed by the Bureau, comprising essentially a group of four piezo oscillators, of which three are alternative standards and the fourth a reference point. Variations in frequency within the group can be measured to one part in 10^8. The crystals are of 30° cut and vibrate on a thickness frequency. They are doughnut shaped, this giving a low temperature coefficient (*cf.* Marrison, below). The standard maintains an absolute value of frequency which is known to one part in 10^7.

THE CRYSTAL CLOCK.—W. A. Marrison. (*Proc. Nat. Acad. Sci.*, July, 1930, Vol. 16, pp. 496–507.)

Description of a quartz-controlled clock used in the Bell Telephone Laboratories. A ring-shaped crystal (100,000 p.p.s.) is used, with the plane of the ring parallel to the optical and electrical axes; by suitably proportioning this ring, the temperature coefficient can be made as near to zero as desired at a given temperature, the coefficients for different modes of vibration annulling each other: other shapes (*cf.* preceding abstract) will give this result also, but the ring shape has additional advantages in connection with mounting.

The electrical circuit is so chosen and designed that ordinary changes in filament and plate voltage have very small effects; the oscillating valve is coupled to the output circuits through an intermediate amplifier stage, to avoid reaction on the crystal due to variations in the load circuit. Frequency reduction is carried out in two steps of 10 each, so that one cycle in the output corresponds to exactly 100 vibrations of the crystal. The 1,000-cycle synchronous motor is built into a motor unit including also a small induction starting motor, two generators for producing current at 100 and at 10 p.p.s., and a mercury-damped flywheel for reducing hunting.

An undisturbed long-time performance has not yet been tested, but a comparison between two similar clocks over short periods (a graph over 17 minutes is shown) gave a greatest deviation from the mean of about one part in 100 million. A comparison over a month and a half against time signals showed a total change in rate of 0.14 sec. per day; towards the end of the period the observed variations were of the order of only one or two hundredths of a second per day. The small ageing effect (a gradual gain), continuing over several months but decreasing steadily in amount, cannot yet be assigned definitely to the crystal itself; it may be due to some variable in the mounting or in the electrical circuit. The rate of the clock is best adjusted by means of a small condenser in parallel with the crystal electrodes. The rest of the paper deals with a proposed time signal transmitter governed by such a clock, and with a combined mean solar and sidereal clock controlled by a single crystal.

IMPROVING THE RESONANCE CURVE OF A PIEZO-ELECTRIC FREQUENCY CONTROL CIRCUIT BY COMPENSATING FOR THE SELF-CAPACITY OF THE CRYSTAL BY A BRIDGE CONNECTION. (German Pat. 491603, Int. Stand. Elec. Co., pub. 15th Feb., 1930.)

COMPARAISON DE QUARTZ PIÉZO-ÉLECTRIQUES OSCILLANT À DES FRÉQUENCES VOISINES (Comparison of Piezoelectric Quartz Plates oscillating at Frequencies Very Close Together).—A. de Gramont and G. Mabboux. (*Comptes Rendus*, 16th June, 1930, Vol. 190, pp. 1394–1395.)

In comparing two oscillators with frequencies very close together, certain difficulties arise, due to pulling in and out of tune and to the beat-note becoming inaudible. The former trouble is usually combated by reducing the mutual coupling—but this also decreases the coupling to the receiver: the latter by substituting, for the ear, an indicating instrument—but this must be watched, which is inconvenient. The writers have adopted the following loud speaker method:—the waves coming from the two quartz oscillators are considered as a single wave whose intensity and frequency vary periodically, the intensity variations being very marked while the frequency variations are limited to a narrow band.

This complex wave is made to beat with a heterodyne regulated so as to give a conveniently audible note (500 to 1,000 p.p.s. for example). The gap between this frequency and that of the quartz oscillators avoids all chance of pulling into tune, while the slightly varying frequency of the oscillator waves produces a resultant note of fluctuating loudness. These fluctuations, even when they descend below a semi-tone, are easy to notice, and their frequency is the beat frequency between the two quartz oscillators. An ordinary receiver (detector, l.f. amplifier and loud speaker) allows the ear to follow them. The writers have been able, by this method, to compare two oscillators giving a frequency-difference corresponding to less than one beat per minute on a main frequency of 3 megacycles—*i.e.*, one in 200 million.

SYNTHESIS OF PIEZOELECTRIC PLATES. (German Pat. 491716, Telefunken, pub. 13th Feb., 1930.)

In the making of these plates from crystalline or amorphous materials (referred to in various past abstracts) these materials are heated while under the influence of a strong electric field; the heating loosens the molecular bonds and allows the field to orientate a large number, or almost the whole, of the piezoelectric moments.

PIEZOKWARC W UKLADACH DYNATRONOWYCH (Piezoelectric Quartz in Dynatron Circuits).—J. Groszkowski and W. Majewski. (*Wiadomości i Prace Inst. Radjotech.*, Warsaw, No. 1, Vol. 1, 7 pp.)

A short paper showing the stabilisation possibilities of dynatron oscillators by quartz crystal control.

STABILISING NON-CRYSTALLINE PIEZOELECTRIC PLATES.—Telefunken Co.: A. Meissner. (*Engineer*, 27th June, 1930, Vol. 149, p. 727.)

In 1929 Abstracts, pp. 159 and 582, Meissner's work on the formation of piezoelectric plates from resins and waxes combined with powdered quartz (*e.g.*) was referred to. It was stated that unfortunately the piezoelectric moment, though very high, did not remain constant. In a summary of British Pat. 316628, 1st Aug., 1929, it is here stated that this reduction can be "stopped or completely suppressed by continuously applying a d.c. potential," and a simple valve circuit is given in which this is done; the particular circuit being one in which the piezoelectric plate is used as a microphone.

THE VALVE MAINTAINED QUARTZ OSCILLATOR: DISCUSSION.—J. E. P. Vigoureux. (*Journ. I.E.E.*, July, 1930, Vol. 68, pp. 867–872.)

Discussion of the paper dealt with in June Abstracts, p. 343.

NOTES ON THE DETUNING METHOD OF MEASURING THE HIGH FREQUENCY RESISTANCE OF A CIRCUIT.—E. B. Moullin. (*E.W. & W.E.*, July, 1930, Vol. 7, pp. 367–370.)

After giving the theory on which the change of reactance method is based, and the formulæ employed, the writer discusses certain assumptions tacitly made in deducing these latter. He shows how the non-fulfilment of these assumptions may lead to error: *e.g.*, the method assumes that the effect of the measuring circuit on the generator is inappreciable, while depending on the converse action being appreciable. Even the restoring of the generator current to a fixed value, after each adjustment of the measuring circuit, does not fulfil the assumption exactly, for the frequency change produced by the coupling remains. For accurate results, therefore, a quartz-controlled generator should be used.

Another source of error is the effect of the e.m.f. induced directly in the voltmeter coil; this may generally be recognised by the lack of symmetry in the resonance curve.

STUDY OF THE NATURAL ELECTRICAL OSCILLATIONS OF SOLENOIDAL, PANCAKE AND CONICAL COILS.—I. Yamamoto. (*Sci. Rep. Tohôku Univ.*, Dec., 1929, Vol. 18, pp. 531–579.)

Covering much the same ground as the papers dealt with in 1928 Abstracts, pp. 104 and 582.

RECHERCHES D'ÉLECTROSTATIQUE (Researches in Electrostatics).—R. Darbord. (*Ann. de Physique*, May–June, 1930, Vol. 13, pp. 471–563.)

A long paper dealing with the writer's improvements in apparatus and methods connected with the measurement by the Nernst bridge, at high frequencies, of the dielectric constants of liquids (*cf.* 1928 Abstracts, p. 228). Besides describing in detail his special variable condenser for containing the liquid, he gives a new method of absolute calibration: "one knows the precautions which a measurement of this nature generally requires, and it is interesting to possess an easy method giving results accurate to one thousandth part."

The writer's method employs a quadrant electrometer working on open circuit, and thus he is led to a study of this instrument and the design of simplified methods of determining its principal constants. Electrometer measurements on open circuit are generally troubled by a wandering zero: he examines this phenomenon and shows how it may be avoided. Another piece of apparatus involved is a variable electrostatic coupling with two flat plates with guard ring: this gives exact results, in spite of the imperfect parallelism of the plates: to explain this, he establishes the theory of the "electrostatic wedge." This leads to the study of the electric field between two spheres, and the discharge between spheres.

MEASUREMENTS AT HIGH VOLTAGES.—G. Yoganandam. (*Electrotech.*, Bangalore, Feb., 1930, pp. 271–274.)

A combination of a specially built air-cored current transformer and a capacity-resistance potential transformer which avoids the need of tedious calibration, and with the help of an a.c. potentiometer enables measurements of voltage and current to be carried out with an accuracy of not less than 1 in 1,000 parts and of phase difference to within 0.05°.

AN ACCURATE METHOD OF TESTING BENT PERMANENT MAGNETS.—C. E. Webb and L. H. Ford. (*Journ. I.E.E.*, June, 1930, Vol. 68, pp. 773–778.)

From the N.P.L. An application of the search-coil method of measuring *H* to the testing of bent magnets, by the use of jointed coils, is described.

The Magnetic Susceptibility of Rubidium.—C. T. Lane. (*Phys. Review*, 15th April, 1930, Series 2, Vol. 35, No. 8, pp. 977–981.)

Ein neues niederohmiges Galvanometer mit kurzer Einstelldauer (A New Low Resistance Quick Reading Galvanometer).—A. Deubner. (*Zeitschr. f. tech. Phys.*, May, 1930, Vol. 11, No. 5, pp. 163–165.)

One pole has a nose which projects into a cavity in the other pole, and the loop (made out of a U-shaped piece of $1\ \mu$-thick aluminium foil) fits into the air-gap thus formed. Sensitivity is 5×10^{-8} A./mm. for 80-times enlargement, and the spot takes up its position in 0.2 sec. (for open circuit) and 0.4 sec. (for short circuit).

Measurement of the Resistance of Earth Connections.—P. Mocquard. (*Ann. des P.T.T.*, Dec., 1929, pp. 1085–1089: summary in *Science Abstracts*, Section B, May, 1930, Vol. 33, p. 297.)

A method resembling that used by the German Post Office.

Zur Messung der elektrischen Leitfähigkeit der Erde durch Induktion (On the Measurement by Induction of the Electrical Conductivity of the Earth).—I. Königsberger. (*Physik. Zeitschr.*, 15th May, 1930, Vol. 31, No. 10, pp. 487–498.)

An experimental method for the determination of the electric conductivity of the earth at great depths is described, depending on the imposition of an artificial electromagnetic field by means of a circular current of large but finite radius, flowing in a fine wire. A mathematical calculation is first made of the vertical component of the magnetic intensity when the wire lies in an infinite plane bounding an infinitely conducting semi-space. Skin-effects, small phase differences and screening effects are initially neglected; the inaccuracies thus caused are estimated. The resulting semi-empirical formula is discussed and tested by observation.

The theory is then applied to the earth considered as such a semi-space; observations give a value of the resistance of the upper layers of the earth of the order of magnitude expected ($3.10^4\ \Omega$ per ccm.). Frequencies $<$ 500 cycles/sec. must be used in order to reach distances from 1 km. to 20 km.; the sources of experimental error and difficulties thus arising are shortly discussed.

An Investigation of Earthing Resistances.—Higgs. (*See under* "Miscellaneous.")

Dielectric Constants of Water and Hydrogen Peroxide.—Cuthbertson and Maas. (*Nature*, 10th May, 1930, Vol. 125, p. 724.)

Abstract only of papers in the Journal of the American Chemical Society, February, 1930, on measurements of the dielectric constant of water, hydrogen peroxide and its aqueous solutions at various temperatures.

Thomson Effect in Zinc Crystals.—L. A. Ware. (*Phys. Review*, 15th April, 1930, Series 2, Vol. 35, No. 8, pp. 989–997.)

Nomograms: a Summary of their Theory and a Description of their use for Complex Hyperbolic Functions and for Conversion between Rectangular and Polar Coördinates.—J. Rybner. (*Gen. Elec. Review*, March, 1930, Vol. 33, pp. 164–179.)

Bestimmung des Krümmungsmittelpunktes der Integralkurve beim Blaessschen Integrationsverfahren (Determination of the Centre of Curvature of Integral Curves by the Blaess Integration Process).—W. M. Z. Capellen. (*Zeitschr. f. tech. Phys.*, July, 1930, Vol. 11, No. 7, pp. 259–260.)

Probable Values of the General Physical Constants, as at 1 January, 1929).—R. T. Birge. (*Phys. Review*, Suppl. 1, No. 1, Vol. 1, 1929, pp. 1–73; correction p. 241, No. 2.)

SUBSIDIARY APPARATUS AND MATERIALS.

Note on a Method of Measuring Cathode Ray Oscillograph Figures.—R. M. Wilmotte. (*Journ. Franklin Inst.*, June, 1930, Vol. 209, No. 6, pp. 809–813.)

A short description of a method of calibration of the cathode ray oscillograph which automatically eliminates the various causes of error in the linearity of the calibration of the tube. The method is applicable only to the case when an apparently stationary image is produced on the screen.

The method was employed in an experiment in which the time scale was produced by means of a rotating potentiometer; the maximum voltage of a recurring wave form of very irregular shape was to be measured. "During every other rotation of the potentiometer brush, the deflecting plate of the oscillograph was disconnected from the apparatus producing the wave form under examination and, instead, was connected to a d.c. voltage of known value." "The resulting image on the screen as seen by the observer consisted of the wave form under examination and a straight line." The d.c. voltage was adjusted until the line was a tangent to the highest point of the wave form curve. The value of d.c. voltage required was taken to be equal to the maximum voltage of the wave form.

Extensions of the method to (*a*) reproduction of the whole image, (*b*) measurement of ellipses, and (*c*) the case of very high frequencies, are briefly described.

Variation of Curvature of a Cathode-Ray in a Magnetic Field.—R. Whiddington. (*Proc. Leeds Phil. and Litt. Soc.*, Dec., 1929, Vol. 2, pp. 18–20; summary in *Science Abstracts*, Sec. A, June, 1930, p. 607.)

The writer suggests that the main part of the variation of the curvature of the electron paths is due to a negative charge on the glass walls;

he explains how this charge depends on the pressure of the residual gas; in addition to this surface effect, he describes a volume effect, previously unknown, which also depends on the pressure.

Kathodenstrahloszillographen liegender Bauart (C.-R. Oscillographs of Horizontal Design).—A. Matthias, M. Knoll and H. Knoblauch. (*Zeitschr f. tech. Phys.*, July, 1930, Vol. 11, No. 7, pp. 276–282.)

The advantages of a horizontal design are discussed: in particular, such a design lends itself to a more compact lay-out for portable purposes: the h.t. lead can be more easily protected and the pumping plant can be arranged underneath. But the horizontal position requires short tubes and specially rigid construction of the electrodes, etc. Such a special equipment is described and illustrated: it gives internal or external recording, and has an overall length of 1.1 m.

Deflection by the earth's magnetic field is avoided by the shortness of the ray. The discharge tube is of metal, which also has the effect of screening against electrical and magnetic influences. The tube and its special Lenard window has already been described by Knoll and von Borries (June Abstracts, p. 345). In spite of its short length, the tube has a maximum sensitivity of 0.1 mm/volt for an exciting potential of 75 kv., and the speed for external recording has now been pushed up to about 5,000 km. per sec. See also below.

Fortschritte am Kathodenstrahloszillographen durch Dauerbetrieb mit Metallentladungsröhren und durch Aussenphotographie sehr kurzzeitiger Vorgänge (Progress in C.-R. Oscillographs: Metal Discharge Tubes for Prolonged Running, and External Photographic Recording of Very Rapidly Occurring Processes).—M. Knoll, H. Knoblauch and B. v. Borries. (*E.T.Z.*, 3rd July, 1930, Vol. 51, pp. 966–970.)

The disadvantages of glass discharge tubes (hitherto used almost exclusively in cold-cathode oscillographs) are discussed, and the writers then describe and illustrate their metal discharge-tube design such as is used in the horizontal oscillograph described in the preceding abstract. It is suitable for continuous runs of several hours, at 40–90 kv. and 1–5 mA. The construction of the special reinforced Lenard window is described in detail and illustrated. Examples of external recording at speeds up to 4,800 km./sec. are given.

A Cathode Ray Oscillograph with Norinder Relay.—O. Ackermann. (*Physik. Ber.*, 1st May, 1930, Vol. 11, p. 895.)

A long abstract of the full paper, an abridged edition of which was referred to in July Abstracts, p. 407. Various new points in the design are mentioned, including the introduction of an "electron filter" to keep away the slow electrons which are present in the ray. A metal construction (steel) has been adopted. The Norinder relay and the true deflecting chamber are separated to avoid the disturbing effect of the concentrating coil.

Messung der Eigenzeit eines Klydonographen mittels Wanderwellen bekannter Zeitdauer (Measuring the Natural Time of a Klydonograph by means of Surges of Known Length).—C. Stoerk and T. Bungardean. (*E.T.Z.*, 8th May, 1930, Vol. 51, pp. 676–679.)

A Glow-Discharge Oscillograph.—Y. Ikeda, E. Kato and M. Mori. (*Mem. Faculty Engin.*, No. 3, Vol. 2, 1929, pp. 49–52.)

In an article "On a Kinematograph of Instantaneous Electric State of High Tension Current" the writers show a number of film records made by photographing a glow-discharge tube containing rarefied helium.

An Improved Method of Using a Glow-Discharge Relay Tube.—Meyer. (*See* abstract under "Acoustics.")

Die behinderte Glimmentladung (The Impeded Glow Discharge).—A. Güntherschulze. (*Zeitschr. f. Phys.*, Vol. 61, Nos. 1/2 and 9/10. pp. 1–14 and 581–586.)

An investigation of the phenomenon, thus named by Seeliger, of a glow discharge which is prevented from starting by a surface brought close to the cathode.

The Correlation of the A.C. and D.C. Striking Voltages of a Neon Lamp.—L. E. Ryall. (*Journ. Scient. Instr.*, June, 1930, Vol. 7, pp. 177–186.)

"The performance of neon discharge lamps near the striking voltage is investigated to determine under what conditions the d.c. striking voltage is constant, and their behaviour at currents ranging from normal working currents down to a few microampères is studied. The effect of substituting for the d.c. voltage an a.c. voltage equal to the d.c. striking voltage is considered, and the a.c. striking voltage as predicted from d.c. phenomena is found to be in agreement with experiment."

It is shown that, provided reasonable care is taken in the selection of the lamp, the a.c. striking and extinguishing voltages are constant and independent of frequency for all frequencies above 25 per sec. The reduction of these voltages for frequencies below this is in agreement with the results obtained from the d.c. phenomena.

The Magnetic Characteristics of Nickel.—F. Tyler. (*Phil. Mag.*, May, 1930, Series 7, Vol. 9, pp. 1026–1038.)

Instrument Transformers.—J. G. Wellings and C. G. Mayo. (*Journ. I.E.E.*, June, 1930, Vol. 68, pp. 704–719: Discussion 719–735.)

La Variation de la Perméabilité dans les Transformateurs téléphoniques (Variation of Permeability in Telephonic Transformers).— —. Loubry. (*Bull. d. l. Soc. franç. d. Élec.*, March, 1930, Vol. 10, pp. 321–327.)

Thickness of Film in Copper Oxide Rectifiers. —W. Schottky and W. Deutschmann. (*Physik. Zeitschr.*, 15th Nov., 1929, Vol. 30, pp. 839–846.)

By the method described, the thickness was found to be between 3×10^{-6} and 3×10^{-8} cm.

Prove su Raddrizzatori ad Ossido di Rame (Tests on Copper Oxide Rectifiers).—G. Sacerdote. (*L'Elettrotec.*, 15th February, 1930, Vol. 17, pp. 106–110.)

Experimental work in connection with the theoretical treatment in the writer's paper dealt with in June Abstracts, p. 333.

Hochspannungs — Quecksilberdampf — Gleichrichter zur Speisung von Röhrensendern (The High Voltage Mercury Vapour Rectifier for the Supply of Valve Transmitters).—Fr. Mertens. (*E.T.Z.*, 27th Feb., 1930, Vol. 51, pp. 305–307.)

Les Redresseurs à Vapeur de Mercure utilisés dans les Postes d'Émission de T.S.F. (Mercury Vapour Rectifiers used in Wireless Transmitting Stations).—Fr. Mertens. (*Génie Civil*, 28th June, 1930, Vol. 96, pp. 640–641.)

Summary of the article referred to above. " The author shows the great advantage of these rectifiers over h.t. dynamos on the one side and rectifiers of the kenotron type on the other ; while dynamos give rise to a 15 per cent. loss and kenotrons to about 20 per cent., the actual efficiency of mercury vapour rectifiers is about 99.5 per cent. and is greater the higher the voltage ; moreover the life is almost infinite. One of the latest types is used in a large Marconi Station at Chelmsford " (400 kw. at 1,200 v.).

Über Elektroden für die Zwecke der Prüfung fester Isolierstoffe (Electrodes for Testing Solid Insulating Materials).—G. Pfestorf. (*E.T.Z.*, 20th Feb., 1930, Vol. 51, pp. 275–278.)

High Permeability Alloys. (*Wireless World*, 21st May, 1930, Vol. 26, pp. 538–541.)

An article by the Research Staff of R.I., Ltd., dealing with nickel-iron alloys and their application to the construction of transformers and chokes. The most useful alloys can be divided into two well-defined groups ; the one group, after Yensen, containing approximately 50 per cent. of nickel and 50 per cent. of iron, and the other group about 78 per cent. of nickel and 22 per cent. of iron.

The magnetic permeability of these alloys varies from about twice to about six or seven times that of the best silicon-steel materials. Unfortunately, the new alloys have economical working flux densities much less than that of silicon steel, and consequently more primary turns are required for their use on mains voltages and mains frequencies. But in l.f. intervalve transformers, which are not required to deliver any appreciable power but in most cases merely to give a step-up voltage from primary to secondary, actual power efficiency need not be considered. Operating on " no load," l.f. intervalve transformers with high-permeability alloy cores have given extremely satisfactory performances. The authors consider that such transformers have an immediate application.

Untersuchungen über die Permeabilität des Eisens bei Wellenstrommagnetisierung (Investigations on the Permeability of Iron for Wave Current [Simultaneous A.C. and D.C.] Magnetisation).—A. Ebinger. (*Zeitschr. f. tech. Phys.*, June, 1930, Vol. 11, No. 6, pp. 221–227.)

Properties of Sheet Magnetic Materials.—B. G. Churcher. (*Electrician*, 29th Nov., 1929, Vol. 103, pp. 659–662 ; summary in *Science Abstracts*, Sec. B., April, 1930, p. 224.)

Some Accessory Apparatus for Precise Measurements of Alternating Current.—R. S. J. Spilsbury and A. H. M. Arnold. (*Journ. I.E.E.*, July, 1930, Vol. 68, pp. 889–897.)

From the N.P.L. Deals with recent designs of air-cooled non-inductive resistances and high-ratio current transformers. A discussion is given on pp. 906–911.

Beeinflussung von Schaltvorgängen durch Elektronenröhren (Switching — Relay — Control by Thermionic Valves).—W. Fischer and L. Pungs. (*Zeitschr. f. hochf. Tech.*, June, 1930, Vol. 35, pp. 205–212.)

The writers have already dealt with the use of a valve, with a high-inductance choke in the anode circuit, as a relay in high-speed telegraphy (*ibid.*, 1926, p. 51). Apart from this special application, the control of switching operations by such a device has great interest—*e.g.*, in conjunction with magnetic relays for the suppression of echoes on long-distance telephone lines and for duplex switching for wireless telephony ; recently also for switching operations in Power work. In such processes the important points are the steepness of the current-increase curve, and the switching time ; above all, the dependence of these quantities on the voltages and valve constants. By graphical methods this information can only be obtained by repeated and laborious constructions, so the writers set out to obtain a practical mathematical treatment of the problem with the help of ideal characteristics, limiting themselves to the case where the circuit to be switched contains inductance (*e.g.*, relay or control choke), though a similar method is applicable to capacity circuits. Their conclusions are verified by experiment.

Three cases are examined, corresponding to zero, negative, and positive grid voltages. The following conclusions are reached :—In all cases, the starting tangent of the current-increase curve cannot be greater than in the equivalent resistance connection without a valve, under the same conditions of voltage, final current and inductance. From the practical point of view, however, it must be remembered that the resistance connection under these conditions is quite unworkable owing to sparking at the switch contact, whereas the valve connection gives absolutely sparkless working. In addition to this fundamental advantage, the choice of valve data gives the chance of obtaining a switching-on curve of trapezoidal form, the more so the smaller the internal resistance R_i and the greater the grid voltage V_g; or better, the greater the value $i_1 = \frac{V_g}{DR_i}$, *i.e.*, the smaller the value DR_i (as usual, $D = \frac{1}{\mu}$), which is the condition for maximum steepness.

For switching-off, negative bias is applied to the grid. If it is just so large that no current of repose is flowing, an exponential current fall is obtained ; for still greater negative values the steepness of the fall is increased and the switching-off curve approaches the trapezoidal form.

Bernstein in der Technik (Technical Applications of Amber).— —. Grunow. (*Zeitschr. V.D.I.*, 21st June, 1930, Vol 74, p. 879.)

Surface Resistivity Measurements on Solid Dielectrics.—L. Hartshorn. (*Proc. Physical Soc.*, 15th June, 1930, Vol. 42, Part 4, pp. 300–308.)

Der Teildurchschlag von festen Isolatoren (Partial Breakdown of Solid Insulators).—A. Walther and Lydia Inge. (*Naturwiss.*, 30th May, 1930, Vol. 18, pp. 528, 529.)

A New Electrolytic Condenser.—Sprague Spec. Company. (*QST*, May, 1930, Vol. 14, pp. 54 and 80.)

The anode is a corrugated aluminium cylinder giving large effective surface area. Capacity 8 microfarads at 400 V., series leakage current after 5 minutes' operation 0.3 mA. or less. Overall size 5in. long by 1⅜in. diameter.

Why Condensers Die.—A. L. M. Sowerby. (*Wireless World*, 4th June, 1930, Vol. 26, pp. 580–583.)

Dealing with the peculiarities of waxed paper as a dielectric. If it were possible to preserve the condenser from all external influences, it should continue indefinitely to remain in a good condition, provided that it is never subjected to a voltage high enough to cause damage to the paraffin wax constituting the dielectric. But in practice a condenser deteriorates steadily from the time of leaving the factory. The primary cause of the deterioration is to be found in the absorption of moisture from the atmosphere ; the paraffin wax is very hygroscopic, and its dielectric properties suffer very considerable damage when it is contaminated with even small traces of moisture.

Sur le Mécanisme de la Rectification dans le Redresseur à Oxydule de Cuivre (On the Mechanism of Rectification in the Copper-Oxide Rectifier).—H. Pélabon. (*L'Onde Élec.*, May, 1930, Vol. 9, pp. 229–244.)

Author's summary :—" The direction of the current rectified by oxidised copper is not that indicated by theory, if one considers only the bad contact formed by the electrode against the oxidised surface. The writer shows that in the interior of the layer of oxide there exists another bad contact, more strongly rectifying, which allows current to pass more readily in the direction oxide-copper. The theory therefore agrees with experiment. He studies also the effects of the pressure exerted by the contact electrode, of the nature of this electrode, and of the voltage." This secondary, internal bad contact—to which the rectifying action is due—is formed " independently of our will " during the oxidation of the metal in air. *Cf.* same writer, June Abstracts, pp. 346–347.

The Theory of the Valve Electrode : Anodic Behaviour of Aluminium.—W. J. Muller and K. Konopicky. (*Zeitschr. f. phys. Chem.* Dec., 1929, pp. 241–256.)

A defence of their previous work (April Abstracts, p. 228) against Güntherschulze.

Über die Zündgeschwindigkeit bei Quecksilberdampfgleichrichtern (On the Striking Velocity in Mercury Vapour Rectifiers).—W. Krug. (*Zeitschr. f. tech. Phys.*, June, 1930, Vol. 11, No. 6, pp. 227–229.)

Podstawy obliczenia prostownika Kenotronowego wysokiego Napiecia (The Principles of Design of H.T. Kenotron Rectifier).—J. Groszkowski. (*Wiadomošci i Prace Inst. Radjotech.*, Warsaw, No. 1, Vol. 1, 35 pp.)

The author investigates the kenotron rectifier as an a.c./d.c. convertor. He gives formulæ for determining the principal working characteristics (rectified voltage, input and output power, efficiency and fluctuations as function of the rectified current). The working characteristic is divided into two parts, where the anode current/time curve can be considered as triangular and as trapezoidal respectively. The increase of the emission current under the action of the hot anode and of the anode high potential is taken into consideration. Finally, simple formulæ for the practical design of a smoothing circuit are given. The paper ends with a numerical example.

Eine elektroosmotische Theorie des elektrolytischen Gleichrichters (An Electro-Osmotic Theory of the Electrolytic Rectifier).—A. Dobias, L. Kramp and O. Lebedinskaja. (*Zeitschr. f. Phys.*, 7th May, 1930, Vol. 61, No. 11/12, pp. 852–872.)

An explanation on the basis of an electro-osmotic displacement of the electrolyte in the pores of the insulating skin on the metallic electrode. In the active phase, this displacement leads to direct contact ; in the passive phase, it produces a condenser with varying capacity.

Contact Rectification. I.—Classification of Contact Rectifiers.—M. Bergstein. (*Am Electrochem. Soc.*, May, 1930, 8 pp.)

The literature is reviewed. Contact rectifiers may be divided into those with integral junctions, *e.g.*, the copper-cuprous oxide type, and those with non-integral junctions, where the electrodes are brought merely into intimate contact by pressure

—as in the cupric sulphide-magnesium type. Further classification is based on the chemical nature of the electrodes. In general, rectified current flows from the electronegative to the electropositive member, but in some cases the reverse is reported. For the cupric sulphide-magnesium rectifier, this reversal is shown to be related to the voltage across the junction.

PROGRESSI NELLA TECNICA COSTRUTTIVA DEGLI ISOLATORI SENZA CEMENTO (Progress in the Constructional Technique of Cement-less Insulators).—E. Alessandri. (*L'Elettrotec.*, 5th April, 1930, Vol. 17, pp. 222–224.)

VARIETIES AND USES OF MICA : II.—A. R. Dunton and A. W. Muir. (*Electrician*, 13th June, 1930, Vol. 104, pp. 757–760.)

Continuation of the paper referred to in July Abstracts, p. 409. Hand-built and Tower-built Micanite—A New Synthetic Bond [Glyptal—*see* July Abstracts, p. 409]—Flexible Micanite—Mica Fabrics—A new Vitreous Product [Mycalex—*see* 1929 Abstracts, p. 462].

LA THÉORIE DE L'ABSORPTION ET LES PERTES DANS LES DIÉLECTRIQUES (The Absorption Theory and Losses in Dielectrics).—S. M. Braguine. (*Elektritchestvo*, Sept., 1929, pp. 440–443.)

New researches on the subject. A summary is given in *Rev. Gén. de l'Élec.*, 11th Jan., 1930, p. 56.

DEVELOPMENTS IN COMMUNICATION MATERIALS.—W. Fondiller. (*Bell Tech. Journ.*, April, 1930, Vol. 9, No. 2, pp. 237–257.)

The paper covers broadly the materials used in communication engineering and gives instances in which the needs of the telephone plant imposed requirements which were not satisfied by commercially available materials. Problems involving the use of duralumin for radio broadcasting transmitters and the light valve used in sound pictures are also described.

THE PREPARATION OF MIRRORS BY SPUTTERING METALS ON TO GLASS SURFACES.—A. C. G. Beach. (*Journ. Scient. Instr.*, June, 1930, Vol. 7, pp. 193–195.)

WIRELESS AND PIRACY : INGENIOUS ARRANGEMENT FOR OUTWITTING THE PIRATES OF BIAS BAY. (*Electrician*, 6th June, 1930, Vol. 104, p. 740.)

An automatic transmitter brought out by the Marconi International Communication Company ; it is fitted in a fire-proof safe, together with the necessary supply of power. Once started, it transmits uninterruptedly the ship's call sign and the distress call.

A FURNACE FOR THE RAPID CALIBRATION OF THERMOCOUPLES [BY THE "GOLD WIRE" METHOD].—F. Adcock. (*Journ. Scient. Instr.*, June, 1930, Vol. 7, pp. 196–197.)

SOLDERING METAL TO PORCELAIN AND GLASS.—D. A. Johnson and W. K. Naylor. (*Elect. Journ.*, Dec., 1929, Vol. 26, pp. 566–567.)

HEATING AND CURRENT-CARRYING CAPACITY OF BARE CONDUCTORS FOR OUTDOOR SERVICE.—O. R. Schurig and C. W. Frick. (*Gen. Elec. Review*, March, 1930, Vol. 33, pp. 141–157.)

ÜBER EINE NEUE FORM DES JAMINSCHEN INTERFERENZ-REFRAKTOMETERS (A New Form of the Jamin Interference Refractometer).—F. F. Martens. (*Zeitschr. f. Phys.*, 8th April, 1930, Vol. 61, No. 5/6, pp. 363–367.)

The older form can be shortened by a half, and rendered more vibration-proof, by the use of a total reflection prism. This enables the two parallel plates to be combined into one, and allows the substance under investigation to be traversed twice by the same ray. The arrangement can be applied also to the investigation of a sound field.

A METHOD OF COINCIDENCE COUNTING.—W. Bothe. (*Zeitschr. f. Phys.*, No. 1/2, Vol. 59, pp. 1–5.)

An arrangement is described for indicating and summing up automatically the coincidences between the strokes of two counters, such as the Geiger ion counter.

MACHINE POUR CALCULER AU MOYEN D'UN PLANIMÈTRE L'INTEGRALE DU PRODUITS DE DEUX FONCTIONS (Machine for Calculating, by means of a Planimeter, the Integral of the Products of Two Functions).—A. Nessi and L. Nisolle. (*Comptes Rendus*, 23rd June, 1930, Vol. 190, pp. 1479–1481.)

EIN NEUER ELEKTRISCHER MEHRFARBENSCHREIBER (A New Electrical Multi-Colour Recorder).—W. Geyger. (*Physik. Ber.*, 1st May, 1930, Vol. 11, pp. 871–872.)

Long abstract of a paper describing a new "point" recorder for the simultaneous recording of several physical processes on the same paper strip in different colours.

A NEW PARALLEL PLATE COMPARATOR.—J. W. Du Mond. (*Review Scient. Instr.*, Feb., 1930, Vol. 1, No. 2, pp. 84–87.)

For measuring the interval between two parallel lines on the same photographic plate.

STATIONS, DESIGN AND OPERATION.

AIRPLANE RADIOPHONE COMMUNICATION EXPERIMENTS [ON SHORT—30–190 M.—WAVES].—C. H. Vincent. (*QST*, May, 1930, Vol. 14, pp. 9–15.)

A description of tests in transmission and reception by day between Diesel-driven aeroplanes (free, therefore, from ignition interference) and a ground station. The writer sums up his conclusions as follows :—Daylight communication seems reasonably practical and reliable on frequencies between 4,500 and 6,000 kc. [about 50–70 m.] at distances up to 200 miles or more. The aeroplane transmitter should have an output of about 100 w. and the ground station 250 to 1,000 w., both with a fairly high percentage of modulation. 34 m. wave signals disappeared completely over a considerable range. The best aerial was a doublet type, each half stretching from the main wing spar as near the end as possible, back towards the tail and then forward to the pyrex bowl insulator carrying through to the cabin. If the wings are short the wire may have to zig-zag more, but this is preferable to the use of loading coils. The short vertical aerials used for weather-report and beacon service would call for much higher powers. As regards night flying, it is thought that the same or better results would be obtained on waves around 100 metres.

Rugby Shortwave Transmitter. Description of GBU and GBW Stations—Modulation and Keying—Power Supply—Control and Safety Devices.—H. G. Whiting. (*Electrician*, 18th and 25th July, 1930, Vol. 105, pp. 76–77 and 113–114.)

Swedish Broadcasting Stations: Field Strength Measurements.—Lemoine. (*See* abstract under "Propagation of Waves.")

Der Nachrichtendienst der Luftfahrt (Aircraft Communication Organisation—particularly in Germany).— —. Kölsch. (*Europ. Fernspr:dienst*, July, 1930, pp. 235–243.)

International [Amateur] Communication on 28 Megacycles.—C. C. Rodimon. (*QST*, May, 1930, Vol. 14, pp. 21–25.)

Reports of stations in Great Britain, Finland, Denmark, France, S. Africa, China, Canada, Australia, New Zealand, the Netherlands, and the U.S.A. itself.

GENERAL PHYSICAL ARTICLES.

Electronic Conduction and Ionization in Crossed Electric and Magnetic Fields.—N. Minorsky. (*Journ. Franklin Inst.*, June, 1930, Vol. 209. No. 6, pp. 757–775.)

A theoretical study of the trochoidal scattering of electrons in crossed electric and magnetic fields. A method is developed "based on the assumption of a certain simplified mechanism of scattering in which instead of the double infinity of trajectories generated by collisions, one single trajectory is considered. To this average trajectory is attached a certain statistical weight resulting from the geometry of trochoidal motions." The length of one trochoidal loop is assumed to be small in comparison with the mean free path. "The electronic motions occurring in an inert gas under the specified conditions are found to be characterised by a trochoidal field of electronic trajectories having the property that the rolling radius $a = E/kH^2$ and the orbital period $T = 2\pi/kH$ are constants of the field depending only on E and H." Curves showing the distribution of electrons on various trajectories plotted against the number of collisions with the gas particles are given: the theoretical negative space charge density is plotted against the distance from the cathode. "The potential difference across the gas in which the trochoidal field of electronic trajectories is established depends on two independent parameters, H and λ [the mean free path]. With the assumed mechanism of collisions, the action of H analytically corresponds to the variation of the upper limit of integration of the one dimensional Poisson's equation applied to the trochoidal field and the action of λ to that of an independent parameter of the integrand." The investigation can be extended to take into account the case of non-elastic impacts.

Experimental curves are given showing (1) the relation of the potential difference across the gas to the strength of the radial magnetic field for different values of the gas pressure and (2) the relation between mean free path and strength of magnetic field for different given values of the current through the gas.

Oscillations in the Glow Discharge in Neon.—G. W. Fox. (*Phys. Review*, 1st May, 1930, Series 2, Vol. 35, No. 9, pp. 1066–1072.)

Author's abstract:—Radio-frequency oscillations consisting of one or two fundamentals together with a series of harmonics for each fundamental have been observed in large current glow discharges in neon. The observed frequencies lie in the range from approximately 1.5×10^4 to 2×10^5 cycles/sec. The oscillations are very sensitive to pressure changes, their frequency increasing rapidly with decreasing gas pressure. The oscillation frequency also increases markedly with increasing current. The frequency is quite independent of resistance in series with the discharge.

The suggestion is made that the oscillations are due to the presence of a reversed electric field in the negative glow of the discharge.

Schwankungserscheinungen und Lichtzerstreuung (Fluctuation Phenomena and Scattering of Light).—M. Didlaukies. (*Ann. der Physik*, 1930, Series 5, No. 2, pp. 205–243.)

Containing paragraphs on application of Fluctuation Theory to dielectric constants and density and to the Kerr effect in substances composed of dipoles.

The Numerical Solution of Partial Differential Equations.—G. Prasad. (*Phil. Mag.*, June, 1930, Series 7, Vol. 9, No. 61, pp. 1074–1081.)

The Ionization of Hydrogen by Single Electron Impact.—W. Bleakney. (*Phys. Review*, 15th May, 1930, Series 2, Vol. 35, No. 10, pp. 1180–1186.)

Über die Elementarvorgänge bei Ionen- und Elektronenstoss (The Elementary Processes in Ion and Electron Collision).—H. Kallmann and B. Rosen. (*Zeitschr. f. Phys.* 21st March, 1930, Vol. 61, No. 1/2, pp. 61–86.)

Das Verhalten hochangeregter Atome in elektrischen Feldern (The Behaviour of Highly Excited Atoms in Electric Fields).—H. Kuhn. (*Zeitschr. f. Phys.*, 7th May, 1930, Vol. 61, No. 11/12, pp. 805–815.)

The Motion of Slow Positive Ions in Gases.—J. S. Thompson. (*Phys. Review*, 15th May, 1930, Series 2, Vol. 35, No. 10, pp. 1196–1216.)

Ionisatie door metastabiele Atomen (Ionisation by Metastable Atoms).—F. M. Penning. (*Physica*, No. 2, Vol. 10, 1930, pp. 47–60.)

If the theory is correct, the sparking potential of a definite gas mixture must increase if the life of the metastable atoms is diminished, and *vice versa*. Experiments are described which confirm the theory.

MISCELLANEOUS.

AN INVESTIGATION OF EARTHING RESISTANCES.—P. J. Higgs. (*Journ. I.E.E.*, June, 1930, Vol. 68, pp. 736–750.)

From the N.P.L. Author's summary:—The phenomena of polarisation and endosmose which accompany the flow of direct current in soil were investigated in various laboratory experiments. Polarisation was an effect of gas bubbles on the measured soil resistance—bubbles which formed owing to a small electrolytic decomposition of the soil moisture by the current and which accumulated at the electrodes. Endosmose was extensive and occurred even against an appreciable hydraulic back-pressure. The earthing resistances of electrodes of inextensive area depend directly on the resistivity of the surrounding soil, and so relations were obtained showing the effect of moisture, temperature and salt on soil resistivity. The resistivities of coal, coke, ashes, chalk and dried soil were also obtained.

Various types of electrodes of inextensive area, viz., pipes, plates and strips, were installed in a plot of ground and tested over a period covering one year. The results are important as being typical of what may be obtained in practice, but not as criteria of comparative utility of the various electrode types on account of the soil resistivity being—there were reasons to presume—appreciably non-uniform. The earthing resistances of the various electrode types were, however, calculated theoretically, a soil of uniform resistivity being assumed, and the results obtained may be used as criteria. The seasonal variations in resistance were determined during the year, and the effect of moisture in this respect was greater than that of temperature.

Some electrodes of extensive area, viz., water pipes, the lead sheath of a large size cable and the steel structures of buildings, that were in the vicinity of the other electrodes, were also tested. Their earthing resistances were much smaller than those of the other types, and the smallest resistance was that of a water pipe. The possible differences between alternating-current and direct-current measurements made on electrodes in the field were investigated. The greatest difference obtained was an increase in resistance of about 20 per cent. with direct current and with the positive electrode one of inextensive area.

The various types of electrodes of inextensive area are considered theoretically in an Appendix.

SUR LA DISTRIBUTION ÉLECTRIQUE POTENTIELLE AUTOUR D'UNE PRISE DE TERRE PONCTUELLE DANS UN TERRAIN À COUCHES HORIZONTALES HOMOGÈNES ET ISOTROPES (The Potential Distribution around a Point Earth in Horizontally Stratified Ground).—S. Stefanesco and C. and M. Schlumberger. (*Journ. de Phys. et le Rad.*, April, 1930, Series 7, Vol. 1, pp. 132–140.)

ON THE MEASUREMENT BY INDUCTION OF THE ELECTRICAL CONDUCTIVITY OF THE EARTH. Königsberger. (*See* under "Measurements and Standards.")

AN ELECTRO-CHEMICAL METHOD OF ORE-EXPLORATION [PROSPECTING].—A. Matsubara. (*World Engineering Congress Abstracts*, 1929, Paper 383.)

SUR LES PROPRIÉTÉS MAGNÉTIQUES DES ROCHES (The Magnetic Properties of Rocks).—G. Grenet. (*Ann. de Physique*, March, 1930, Vol. 13, pp. 263–348.)

GEO-ELECTRIC PROSPECTING BY A.C. METHODS.—W. Geyger. (*Zeitschr. f. hochf. Tech.*, Dec., 1929, Vol. 34, pp. 228–233.)

Second and final part of this general survey. It deals largely with the "compensation" method using the writer's a.c. compensator.

THE REGISTRATION OF GROUND VIBRATIONS BY A H.F. METHOD.—P. Liechti. (*Gerlands Beitr.*, No. 2, Vol. 23, 1929, pp. 213–228.)

The vibrations set up oscillations on a mercury surface close to a metal plate, these two surfaces forming the condenser of a tuned r.f. circuit.

GEOPHYSICAL PROSPECTING.—H. Haalck. (*Gerlands Beitr.*, No. 2, Vol. 23, 1929, pp. 99–143.)

A comprehensive review of the various electrical methods.

A NEW FLICKER RADIOMETER.—D. C. Stockbarger and L. Burns. (*Pub. Massachusetts Inst. Tech.*, March, 1930, No. 64, pp. 76–83.)

Apparatus based on the fact that when radiation is allowed to pass alternately through two filters having identical transmissions for all wavelengths, except those lying in a narrow spectral region, a flicker is produced which is a function of the intensity of the radiation within that region.

SYSTEMS OF TELEGRAPHY AND TELEPHONY BY MEANS OF PENCILS OF INFRA-RED RADIATIONS.—L. Rolla and L. Mazza. (Summary in *Nature*, 10th May, 1930, Vol. 125, p. 730.)

A paper read before the Royal Academy of the Lincei on Jan. 5th. The rays are generated by an arc of hollow carbons packed with mixtures of halides and oxides of alkali and alkaline earth metals. With 100 w. arcs, telephony was satisfactory over distances exceeding 6 km.

VORRICHTUNG ZUM SCHUTZE DER QUECKSILBER-DAMPFLAMPEN MIT WASSERSTROMKÜHLUNG (Protection Device for Water-Cooled Mercury Vapour Lamps).—L. Piatti. (*Physik. Zeitschr.*, 15th Feb., 1930, Vol. 31, No. 4, pp. 182–184.)

THE CALCULATION OF ABSORPTION IN X-RAY POWDER-PHOTOGRAPHS AND THE SCATTERING POWER OF TUNGSTEN.—A. Claassen. (*Phil. Mag.*, January, 1930, Vol. 9, No. 55, pp. 57–65.)

Temperature Distribution along a Heated Filament used as a Catalyst.—E. S. Lamar and W. E. Deming. (*Phil. Mag.*, January, 1930, Vol. 9, No. 55, pp. 28–36.)

Über die Licht- und Temperaturschwankungen wechselstromdurchflossener Glühlampen (On the Fluctuations of Light and Temperature of A.C. Incandescent Lamps).—J. Kurth. (*Arch. f. Elektrot.*, 5th Nov., 1929, Vol. 23, No. 1, pp. 124–148.)

The light fluctuations were plotted point by point by the use of a synchronously rotating sector-disc and a photo-electric cell. Simultaneously the corresponding current curve was recorded. The curves showed a phase displacement relative to the power curve of about 90 deg. The phase displacement and the fluctuation amplitude depend on frequency, filament thickness and material, temperature and surroundings of the filament. The theory was then worked out, and an improved method of measurement evolved.

Periodische Intensitätsschwankungen der Strahlung von gasgefüllten Glühlampen (Periodic Fluctuations of the Intensity of Radiation, in Gas-filled Incandescent Lamps).—F. Kruger: Schmekel and Langenfeld. (*Zeitschr. f. tech. Phys.*, December, 1929, Vol. 10, pp. 629–634.)

Über die neuesten Fortschritte auf dem Gebiet der Wolframdrahtlampen (The Latest Progress in connection with Tungsten-filament Lamps).—H. Alterthum. (*E.T.Z.*, 28th Nov., 1929, Vol. 50, pp. 1723–1726.)

Über die Aufladung kleiner Schwebeteilchen in der Korona-Entladung (The Charging of Small Suspended Particles in the Corona Discharge).—H. Schweitzer. (*Ann. der Physik*, Jan., 1930, Series 5, Vol. 4, No. 1, pp. 33–48.)

Widerstandsveränderungen bei längsgespanntem Nickeldraht (Variations of Resistance in Longitudinally Stretched Nickel Wire).—R. S. Bedi. (*Physik. Zeitschr.*, 15th Feb., 1930, Vol. 31, No. 4, pp. 180–182.)

The Green Flash in Southern California.—S. J. Barnett. (*Nature*, 22nd March, 1930, Vol. 125, p. 446.)

The Numerical Determination of Characteristic Numbers.—W. E. Milne. (*Phys. Review*, 1st April, 1930, Vol. 35, No. 7, pp. 863–867.)

The Educational Value of the Theorem of Constant Linkages.—F. C. Lindvall. (*Gen. Elec. Review*, May, 1930, Vol. 33, pp. 273–278.)

Among the typical applications in the analysis of problems, the theorem is here applied to time relays of various kinds, to mutually-linked circuits, etc.

High Voltage Corona in Air.—S. K. Waldorf. (*Journ. Am. I.E.E.*, April, 1930, Vol. 49, pp. 273–276.)

" . . . . The theory of the influence of space charge as developed by Holm has been tested by experiment and a marked discrepancy is indicated. Values of power loss due to corona, as measured, differ appreciably from those predicted by Holm, but in general follow the quadratic relation suggested by Peek. Unusually large and clear oscillograms afford much interesting qualitative information as to the influence of space charge travel on corona."

An X-Ray Search for the Origin of Ferromagnetism.—J. C. Stearns. (*Phys. Review* 1st Jan., 1930, Series 2, Vol. 35, No. 1 pp. 1–5.)

The Magneto-Chronograph and its Application to Magnetic Measurements.—H. E. McComb and C. Huff. (*Terr. Magnetism*, No. 2, 1929, Vol. 34, pp. 123–141.)

The use of a beam of light, photoelectric cell, amplifier and chronograph arrangement for observing the swing of the magnet in horizontal intensity measurements reduces the error of such observations to one-fifth of the usual amount.

Electrical Properties and Structure of Metallic Films obtained by Thermic and Cathodic Projection.—F. Joliot. (*Comptes Rendus*, 10th March, 1930, Vol. 190, pp. 627–630.)

Magnetic Hardening.—E. G. Herbert. (*Sci. News-Letter*, 29th March, 1930, Vol. 17, p. 202.)

Metals can be superhardened by magnetic treatment as well as by heat treatment. Magnetic hardening is accomplished by repeatedly changing the polarity of the steel. A specimen so treated could not be hardened more by low temperature annealing. *See* also Feb. Abstracts, p. 113.

Champs magnétiques donnés par le grand Électro-Aimant de Bellevue (Magnetic Fields given by the Great Electro-Magnet at Bellevue).—A. Cotton and G. Dupouy. (*Comptes Rendus*, 3rd March, 1930, Vol. 190, pp. 544–547.)

For measurements of magnetic double refraction see also *Comptes Rendus*, 10th March, pp. 602–606.

Balancing Machine using Piezo-Electricity.—T. Miyamoto. (*World Engineering Congress Abstracts*, 1929, Paper 633.)

An arrangement apparently similar to Langevin's patent (April Abstracts, p. 233).

Balancing Apparatus for Small Rotating Parts.—W. Späth: S. Kuno. (*E.T.Z.*, 16th Jan., 1930, Vol. 51, pp. 86–89.)

(1) Small high-speed parts down to about ¼ lb. in weight are tested by having the vibration due to unbalance counteracted by magnets adjustably

fed with a.c. of rectangular form, from a commutator driven synchronously with the part under test.

(2) A balancing machine in which the indication of balance is given by an optical arrangement of mirrors, etc., and by which the magnitude and direction of the unbalancing force can be determined. The eccentricity of the c. of g. of turbine or electrical rotors is said to be determinable down to about 0.0005 mm.

Spannungsuchgerät (Voltage Searching Apparatus).—Siemens and Halske. (*E.T.Z.*, 1st Nov., 1929, Vol. 50, p. 1701.)

Description of a portable instrument comprising two two-grid valves supplied by pocket-lamp batteries, an exploring coil and telephone headgear, by which the presence of a live cable, its direction, leakage, etc., etc., can be detected even if the supply is d.c.

A New Magnetic Rail Inspection Car.—S. Sakurai. (*World Engineering Congress Abstracts*, 1929, Paper 482.)

A paper dealing with an equipment which would appear to resemble closely the Sperry equipment dealt with in 1929 Abstracts, p. 406.

Recherche des Défauts dans les Pièces ferromagnétiques (Detecting Flaws in Ferromagnetic Articles).—J. Peltier. (*Comptes Rendus*, 5th May, 1930, Vol. 190, pp. 1052–1053.)

Still further development of the work referred to in April Abstracts, p. 233. The use of a 4-stage l.f. amplifier enables the air-gap between pole-pieces and axle under test to be increased to 5 or 7 mm., even with the weak magnetic fields hitherto employed. The writer expects, by increasing these fields, to penetrate much deeper than he has at present and to locate the actual depth of small blow-holes, etc. The speed of rotation at present used is 10–20 turns per sec.

Under-water Explosions studied by Piezoelectric and other Methods.—J. Ottenheimer. (*Génie Civil*, 21st and 28th Sept., 1929, Vol. 95, pp. 273–276 and 295–298.)

The National Physical Laboratory.—(*Electrician*, 23rd May, 1930, Vol. 103, p. 647.)

A summary of the Report for Year 1929.

The Hague Conference: Recommendations of the International Technical Consulting Committee on Radio Communication [C.C.I.R.].—S. C. Cooper: Minutes of Closing Plenary Session, C.C.I.R. (*Proc. Inst. Rad. Eng.*, May, 1930, Vol. 18, pp. 762–774 and 775–795.)

Physics in Relation to Wireless.—W. H. Eccles. (*Nature*, June 14th, 1930, Vol. 125, pp. 894–897.)

From the presidential address to the Institute of Physics entitled "The Influence of Physical Research on the Development of Wireless," delivered on May 27th, 1930.

Economic Quality Control of Manufactured Product.—W. A. Shewhart. (*Bell Tech. Journ.*, April, 1930, Vol. 9, No. 2, pp. 364–389.)

A New High Voltage Research Laboratory.—(*Nature*, March 8th, 1930, Vol. 125, pp. 353–356.)

A description of the high voltage research laboratory of Metropolitan-Vickers Electrical Company, Ltd., at Trafford Park, Manchester.

Reducing Observations by the Method of Minimum Deviations.—E. C. Rhodes. (*Phil. Mag.*, May, 1930, Series 7, Vol. 9, pp. 974–992.)

Vues modernes sur l'Électrostatique (Modern Views of Statical Electricity).—H. Chaumat (*Bull. d.l. Soc. franç. d. Élec.*, No. 98, Vol. 9, pp. 1168–1178.)

See also previous papers by the same author, 1929 Abstracts, pp. 405 and 465. On the experimental side, the writer deals with an electrostatic motor, an electrostatic magnet, etc.

The Engineering Rise in Radio.—D. McNicol. (*Rad. Engineering*, Sept., 1929, Vol. 9, pp. 44–50.)

This 16th part of a long series deals with receiver development from 1912 onwards.

Research, Engineering Development and Production Testing.—A. C. Lescarboura. (*Rad. Engineering*, Sept., 1929, Vol. 9, pp. 37–40.)

Interference between Power and Communication Circuits: Summary (to 1925) of European and American Data.—C. Parker-Smith: S. A. Pollock and W. G. Radley. (*Journ. I.E.E.*, May, 1930, Vol. 68, pp. 587–641.)

Simultaneous Transmission of Two Secret Telephonic Communications: Discussion.—G. Fayard. (*Bull. d. l. Soc. franç. d. Élec.*, March, 1930, Vol. 10, pp. 328–331.)

Discussion on the paper dealt with in June Abstracts, p. 353.

Die Mehrfachausnutzung der Leitungen (The Multiple Use of Communication Lines).—F. Lüschen. (*E.T.Z.*, 23rd Jan., 1930, Vol. 51, pp. 140–148.)

A general survey of progress in multiple telegraphy and telephony over land-lines and cables.

The Motion of Telephone Wires in Wind.—D. A. Quarles. (*Bell Tech. Journ.*, April, 1930, Vol. 9, No. 2, pp. 356–363.)

Two Engineering Photographic Difficulties and Their Solution.—A. W. Swan. (*Engineer*, 16th May, 1930, Vol. 149, p. 543.)

Showing how to photograph (*a*) the interior of a machine or instrument without glare or cross shadows, and (*b*) a reflecting surface such as a mechanism with a glass front, without unnecessary reflections.

Correspondence.

Letters of interest to experimenters are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

The Effect of a Screen on a Receiving Aerial System.

A Plea for a More Scientific Nomenclature.

To the Editor, E.W. & W.E.

SIR,—From time immemorial there has been a tendency for mankind to give a phenomenon a name and consider that they have explained it. No serious consequences result from this practice provided that the name selected does not convey unjustifiable ideas or associations. Many examples of ill-selected terminology might, however, be cited, and one, that is particularly prevalent, is the association of a vocabulary developed partly in electrostatics and partly in magnetostatics with dynamic systems and conditions (*e.g.*, I have before me a technical journal containing an article on the design of transmitting valves for use at high frequencies. In it frequent reference is made to the effects of the " electrostatic field " on the glass at high frequencies, notwithstanding the fact that the field is anything but static).

Unfortunately, the normal mode of teaching the subject but increases the tendency to resolve ideas into distinct electric and magnetic notions, without fully grasping the correlation of the two. There are, however, some text books (*e.g.*, Porter and Foster's Electrical Magnetism : based on the French of Joubert, and Eccles C.W. Wireless Telegraphy), which do attempt a logical treatment of the subject, demonstrating clearly to the student that electricity and magnetism are not two separate entities, but are inter-related in a manner which can be defined both physically and mathematically.

Our first ideas of condenser action were derived from a study of electrostatics, but does this justify us in using such terms as " *electrostatic* induction " when referring to capacitative effects between circuits at *telephone frequencies?* Similarly, in considering the operation of condensers in electrostatics we deal with Faraday lines or electric lines of force. However, when a condenser or capacitative path forms part of a dynamic system surely the radio-scientist should be the first to take into consideration the existence of a displacement current (complete with associated magnetic field.) Yet in the recent contributions on screening in *E.W. & W.E.*, we find such action referred to as an electric effect and as being due solely to the electric " component " of the wave. Why dismember the wave when by changing one terminology and referring to the capacitative effect our difficulty is solved ?

It seems to the writer that the discussion on the subject of screening since Mr. Barfield presented his paper in 1924 (*Journal of the Institution of Electrical Engineers*, Vol. 62, p. 249, 1924) has been hampered by the use of misleading terminology and many have had their electromagnetic faith shaken, without having had substitutes there for any clear conception of the processes involved. Any discussion of the subject to be useful should be based on the experimental results which are available. A basic premise seems to have been lacking and there exists considerable doubt as to just what has been established experimentally. More attention has been paid to the language used in conveying the results than to the results themselves. There can be no doubt as to the actual results obtained, but there is considerable doubt caused by the use of such expressions as : " These experiments clearly demonstrate that it is possible . . . to screen a region from the electric field of an electromagnetic wave without reducing the magnetic field." (See Barfield *loc cit.*, page 259.)

The results of the experiments referred to, from a practical point of view, were that by certain alterations to the system on which the wave acted it was possible to prevent electrical vibrations, produced in the capacitative circuit between the frame and earth, from affecting the receiver which was connected across the frame. Two methods of overcoming this trouble were adopted : the balanced condenser method (*loc. cit.* Fig. 10, p. 257) and the screening method. One point is essential experimentally in this latter method and that is the effective interconnection of the open loop screen and the screen of the receiver which is usually earthed. This is not stressed by Mr. Barfield or in the recent contributions to *E.W. & W.E.*, but it is a basic experimental point which can be tested by any reader.

With a receiver of small dimensions symmetrically placed and connected to a loop remote from earth the antenna effect does not exist and the screen or balanced condensers are unnecessary, but such ideal conditions are seldom met. Introduce an asymmetrical conducting surface such as the earth and we must restore symmetry to the receiver by either connecting the neutralising condensers to the asymmetrical conductor (usually earth) or *connecting the screen to that conductor*. Further light is thrown on the practical side of the question when we remember that a balanced receiver of the "push-pull" type may be used with excellent results to provide the symmetry of operation necessary to avoid the undesired "antenna effect" on the receiver.

Now to these experimental results much suppositious theorising has been added, making use therein of a vocabulary, in the writer's opinion, ill suited to the task and not likely to result in a clear explanation in the simplest possible terms.

Why has it been necessary to omit all such terms as mutual inductance, capacitance, and displacement currents, when considering systems such as those resulting in the so-called "screening from the electric field of the wave"; and why have terms such as electric component of the wave been introduced into the explanation and discussion? It cannot be said that it is for purposes of simplicity and it has certainly resulted in confused ideas on the subject being held by many.

It may be convenient to refer to the currents produced in any portion of a system as due to the varying electric field $\frac{de}{dt} = \text{Curl } H$ in one case, and to the varying magnetic field $\frac{dh}{dt} = \text{Curl } E$ in another; but it is equally possible, and even desirable at times, to reduce our thinking to a "common denominator" and consider all currents produced as due to one and the same physical process. It would seem that some writers would ascribe prescience to a radio wave. It is represented as acting differently upon an element of wire in space which forms a part of an earthed aerial, from the way in which it acts on the same element if it forms part of a loop.

We persist in talking as though the electric field were alone involved in the production of the current in one case and the magnetic field alone in the other. Surely a magnetic field can just as easily produce a current in a single vertical wire aerial as in a single armature conductor in a dynamo and any such element which is "screened" might even justifiably be said to be magnetically screened.

It is not the present purpose to attempt a detailed explanation of the effect of a wave on an electrical system, but rather to plead for a "whole wave" being the cause of one and every current in the system and for a more rational nomenclature. In this particular problem only confusion can result from considering the "components" of the wave as acting separately on the system. It is the system which requires detail consideration and not the wave. In a system with two "degrees of freedom" or two "modes of vibration"—one rotational, the other capacitative to surrounding conductors—we may obviously consider at least two component currents. One of these is useful. The other, the "antenna" current, may result in large unwanted e.m.f.s being applied to the receiver unless special action is taken; and to this end, we have the various methods mentioned above. In all cases the "vertical or antenna" current is produced by the wave, *so that it cannot be reasoned that anything has happened to the wave.* With the so-called electric screen the "antenna current" passes through the screen earth wire or the tube connecting the receiver box and the screen proper; with the balanced condenser and the push-pull systems its path is capacitative; but it always flows. The effect on the receiver, however, may be shown in each method to be neutralised. This is a very different thing from a literal interpretation of "screening from the electric field of a wave." It is neutralising from the effects of the *whole wave* on the capacitative system comprising the frame and neighbouring conductors. Our terminology should suit all three equivalent methods. However, in the case of the usual parlance given above, if it does explain the screen method, it certainly is not readily applicable to the other two methods. (A comparable case of interest in the neutralising of valve amplifiers and the use of screen-grid valves).

This survey is perforce of a very cursory nature, but it is hoped that it may result in some useful discussion on our current terminology which is responsible for much misunderstanding and seeming complexity where none is necessary. Fortunately our faith in the theorems of Maxwell, Poynting and others need not weaken if we recognise that even though a circuit is capacitative, it may still be electromagnetic, and that capacitative effects of the earth can be neutralised or screened from *without affecting any component* of an electromagnet wave. In fact, we may, with complacency, continue to use a loop "screened from the electric component of the wave" to measure field strength in electric units (volts per metre).

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Wellington, New Zealand.

Books Received.

Electric Testing Simplified. By Harold H. U. Cross.

Including a short introductory chapter on the practical units and Ohms law followed by instructions in the use of the measuring and testing instruments generally employed in electrical engineering, including the testing of cells and motor car electrical equipment. Pp. 191 + XV, with 103 illustrations and diagrams. Published by Crosby Lockwood & Son, London. Price 5s. net.

Definition and Formulæ for Students (Light and Sound). By P. K. Bowes, M.A., B.Sc.

Containing, in a brief and compact form, definitions of the technical terms employed in the sciences of light and sound, together with the various formulæ relating to these two subjects, including the staff notation of musical notes and their relative and actual frequencies per second. Pp. 36. Published by Sir Isaac Pitman & Sons, Ltd., London. Price 6d.

Television for All. By C. G. Philp.

A simple explanation for the general public, including Noctovision, Television in colour and Stereoscopic Television. Pp. 82, with frontispiece and 8 diagrams. Published by Percival Marshall & Co., Ltd., London. Price 1s. net.

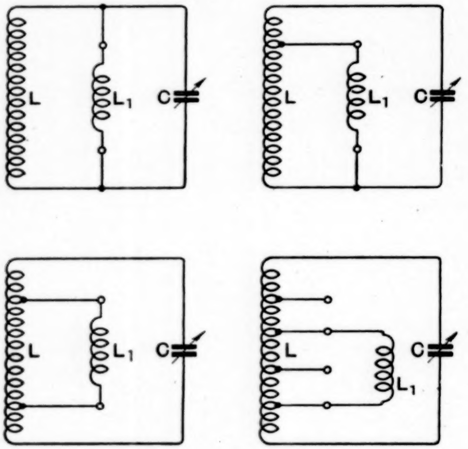
Some Recent Patents.

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each

TUNING ARRANGEMENTS.

Convention date (Germany), 2nd February, 1928. *No.* 305486.

When the tuning range of a circuit is altered by substituting a new inductance coil, the normal coupling of that circuit with any other circuit, such as the aerial, is simultaneously altered, and various consequential adjustments may be necessary to restore the *status quo*. According to the invention, this is avoided by adding one or more parallel inductances to the main tuning inductance in such a manner that there is no mutual coupling between the coils. The Figure shows various ways in which the addition of a non-coupled shunt inductance L_1 is used to alter the tuning range of an oscillatory circuit *L, C*.



No. 305486.

Patent issued to G. C. D. Pfau.

SWITCH-TUNED RECEIVERS.

Convention date (France), 27th October, 1927. No. 299474.

A set comprising one or more stages of H.F. amplification is automatically tuned to any desired wavelength by inserting a multi-contact plug into a socket. A separate exchangeable plug is provided for each transmitting station, the particular contacts being so arranged that, as the plug is inserted, the appropriate aerial and intervalve inductance coils are automatically brought into circuit, and the respective tuning condensers simultaneously set to the correct value. Provision is also made for manual operation of the condensers if necessary to compensate for any subsequent slight change in the wavelength allotted to any particular station.

Patent issued to J. L. Pivert.

STEREOPHONIC WIRELESS.

Convention date (U.S.A.), 8th December, 1927. No 302179.

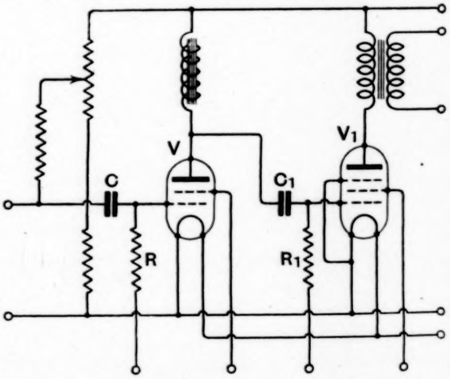
In order to secure a " binaural " effect in wireless reception, two sets of signals are transmitted simultaneously, one upon the upper and the other upon the lower sideband of a modulated carrier wave. The method includes the step of separately modulating portions of a single intermediate-frequency carrier with currents derived from microphones suitably spaced apart to give a stereophonic effect. The system may also be used for multiplex transmission.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

L.F. AMPLIFIERS.

Application date, 17th November, 1928. No. 325023.

For direct sound reproduction a screened-grid amplifier *V* is coupled to a pentode V_1. The input is taken to the control grid through a condenser *C* shunted by a leak resistance *R* carrying a negative bias of 2 volts. The output is coupled to the pentode through a condenser C_1 shunted by a leak R_1 supplied with a negative bias of 14 volts. An anode voltage of 150 is applied to both valves, with 75 volts on the screening-grid of the valve *V*, and 110 volts on the intermediate grid of the pentode. For wireless reception a detector valve is inserted in front of the valve *V*.



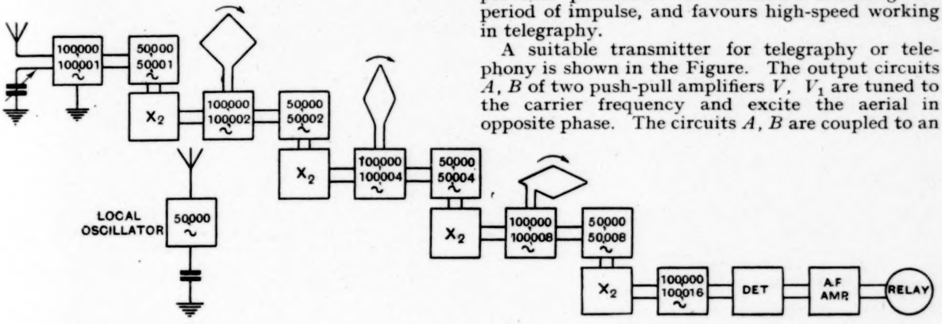
No. 325023.

Patent issued to Gramophone Co., Ltd., and C. O. Browne.

SEPARATING FREQUENCIES.

Convention date (U.S.A.), 2nd November, 1927. No. 299852.

A method of separating one frequency from another slightly different frequency consists in passing both frequencies through a series of heterodyne and frequency-doubling stages in such a way that the desired frequency is maintained at its original value, whilst the undesired frequency is caused to diverge progressively from its original value.



No. 299852.

The arrangement is shown diagrammatically in the Figure. Received frequencies of 100,000 and 100,001 are heterodyned by a local oscillator at 50,000 cycles. The resultant "difference" frequencies are then passed through a frequency-doubler X_2, so that the original frequency of 100,000 is restored and is accompanied by the undesired frequency, now at 100,002. The process is repeated until sufficient divergence has been imparted to the undesired frequency to allow of any ordinary method of separation being applied.

Patent issued to E. G. Gage.

ELIMINATING FADING AND STATIC.

Convention date (France), 3rd April, 1928. *No.* 309022.

Morse messages are transmitted two or three times in succession by ordinary keying and are then similarly repeated by "back-stroke" keying. In reception the successive messages, comprising a certain number of "blanks" due to static, and other "blanks" due to fading, are combined and fed in parallel to the recorder. Under these conditions a signal sign need only figure in one of the received messages to be correctly recorded.

Patent issued to M. de Saivre.

SELECTIVE RECEPTION.

Application date, 10th August, 1928. *No.* 325482. (*Divided out of* 325232.)

In a receiver of the super-regenerative type, periodical quenching of the circuits is effected by intermittently changing the phase of the currents.

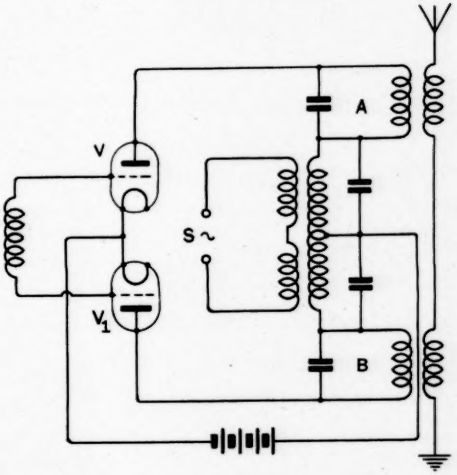
Patent issued to J. Robinson.

SIGNALLING SYSTEMS.

Application date, 10th August, 1928. *No.* 325481. (*Divided out of* 325232.)

Transmission is effected by successive trains of waves of different (*e.g.*, opposite) phase produced by rhythmically changing the phase of the carrier-wave at a frequency independent of the signalling frequency. As a consequence, in reception, the energy applied to the receiving circuits builds up for say 50 cycles, and then, following the phase reversal, the energy is reduced for another 50 cycle period. This prevents persistence of oscillation following the period of impulse, and favours high-speed working in telegraphy.

A suitable transmitter for telegraphy or telephony is shown in the Figure. The output circuits A, B of two push-pull amplifiers V, V_1 are tuned to the carrier frequency and excite the aerial in opposite phase. The circuits A, B are coupled to an auxiliary source S having a frequency, say, of 20,000 cycles, the arrangement being such that when the amplitude of one circuit A is at a maximum that of the circuit B is a minimum, and *vice versa*.



No. 325481.

The resulting radiation undergoes rhythmic changes in phase at the frequency of the source S.

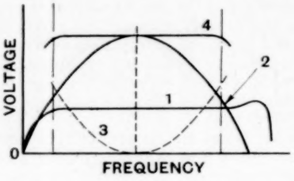
Patent issued to J. Robinson.

INTERVALVE TRANSFORMERS.

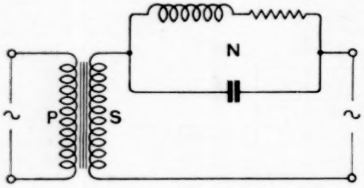
Application date, 17th November, 1928. No. 325288.

A limit is set to the step-up ratio between primary and secondary, owing to the fact that a simple increase in the secondary windings also involves an increase in capacity leakage as well as in resistance damping. For uniform amplification this limit is approximately 1 : 5 or 1 : 6, and corresponds to the curve 1 in Fig. (a). If the step-up ratio is increased the response curve normally takes the form 2. According to the invention, the secondary winding of a high-ratio transformer is combined with an impedance network *N*, Fig. (b), having a voltage-frequency characteristic curve, such as 3, Fig (a), *i.e.*, the "inverse" or reflected image of the curve 2. The combination gives a "flat" response curve 4 at a higher level than the curve 1.

Patent issued to S. G. S. Dicker.



(a)



(b) No. 325288.

TELEVISION SYSTEMS.

Application date, 4th October, 1928. No. 324904.

The receiving device consists of a band or strip impregnated with a substance such as potassium ferrocyanide which, when electrolysed, changes colour at one or both electrodes. The sensitised strip is wound around a drum, which is associated with a synchronised rotary switch connected to a series of conductors making light contact with the surface of the drum. The incoming signal currents are thus fed in proper sequence to the sensitised paper so as to make a series of permanent, or semi-permanent, picture records similar to a kinematograph film.

Application date, 5th November, 1928. No. 324949.

At the transmitter a number of banks of light-sensitive cells are placed at different distances from the exploring device, and are controlled by a single switch, in order to make it possible to transmit simultaneously or in rapid succession the images of objects of different sizes, or of objects at varying distances from the main source of light.

Patents issued to J. L. Baird and Television, Ltd

SAFETY DEVICE FOR L.F. AMPLIFIERS.

Application date, 17th November, 1928. No. 325021

The field windings of a moving-coil loud speaker are fed from the filament circuit of the amplifier, and a neon lamp is shunted across the windings so as to act as a safety device by taking the large voltages generated when making or breaking the supply circuit.

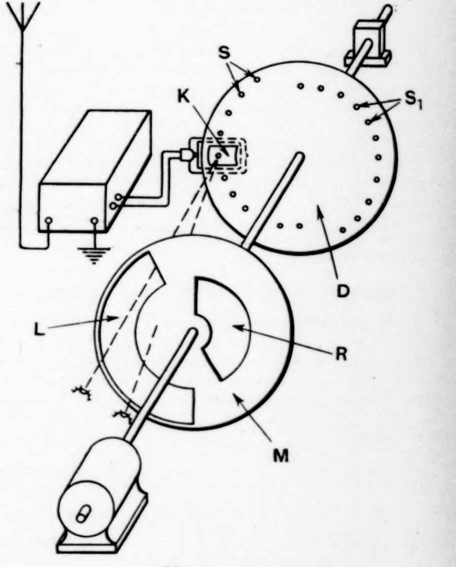
Patent issued to J. L. Gottlieb and Co., Ltd., and J. L. Gottlieb.

STEREOSCOPIC TELEVISION.

Application date, 24th January, 1929. No. 325362.

To secure a stereoscopic effect, two sets of pictures (representing the object as viewed by each individual eye) are transmitted alternately or simultaneously by two separate projectors. In reception, the corresponding signal elements are assembled on the viewing-screen *K* by two separate spirals *S*, S_1 on the disc *D*. A second disc *M*, rotating synchronously with the first, is provided with two slots *L*, *R* which control the observer's vision, so that one picture is seen only by the right eye, and the second only by the left eye, the resultant effect being to throw the parts of the picture into stereoscopic relief.

Patent issued to R. L. Aspden.



No. 325362.